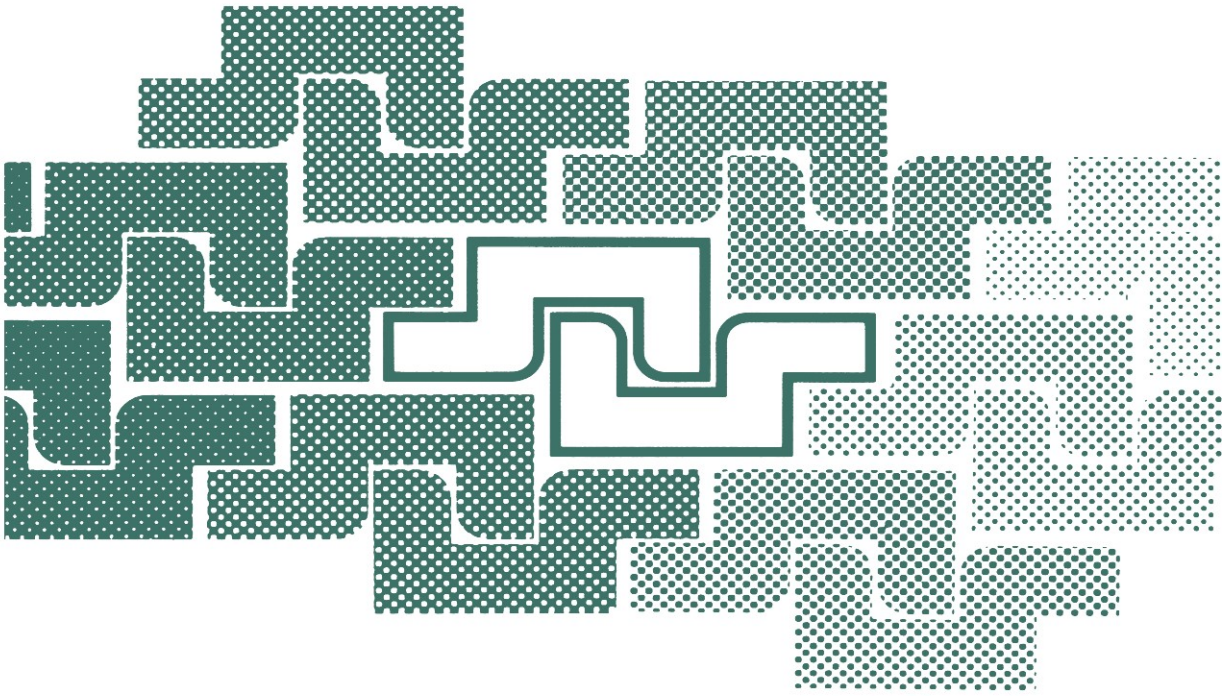
Exhibit 17



Health Related Effects of Phyllosilicates

Edited by J. Bignon

NATO ASI Series

Series G: Ecological Sciences, Vol. G 21

ASBESTOS CONTENT OF TALCS FROM ITALIAN MINES AND FIBRE CONCENTRATION IN VARIOUS COMMERCIAL TALCUM POWDERS USED IN ITALY.

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NATO ASI Series, Vol. G 21
Health Related Effects of Phyllosilicates
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Introduction

Talc naturally occurswith a variety of mineral habits: blocky, platy, polycristalline and fibrous. Due to the geological origin, metamorphic alterations of quartzite and dolomitic rocks, talc deposits have been found to contain talc mineral often in association with other minerals like serpentine and amphiboles. Health interest in the occurrence of the asbestiform varieties of these minerals is determined by the cancerogenic potential associated to the inhalation of asbestos fibres.
Several studies have indicated a close association between fibrous talc and fibrous amphibole (tremolite and anthophyllite) structures (Stemple and Brindley, 1960; Virta, 1985).
In the italian talc deposits serpentine and amphiboles, as accessory minerals, have been found in many mines, most of which are no more exploited today (Marconi et al., 1986, Verdel et al., 1985). In general italian talcs are considered very pure and not contaminated by asbestos or quartz.
The world use of talc during the last years showed a constant increase, due mainly to the increasing contribution of the oriental countries. The estimated production in Italy raised 130.000 tons in 1986, imports from other countries was about 25.000 tons and exports accounted for nearly 40.000 tons (see Figure 1).

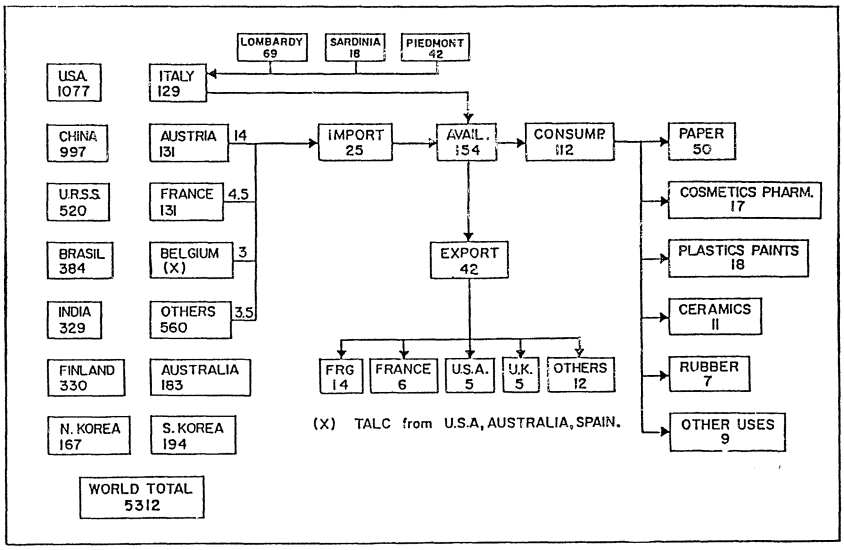

Figure 1 - Talc in the world and in Italy (data from Roskill, 1987 and Soc.Talco e Grafite Valchisone, 1989)

Italian talc active mines are localized in three main areas: Pinerolese (near Turin), Orani (east Sardinia) and Valmalenco (Lombard Alps). Mining trends have been nearly constant for the first two areas but decreasing during the last years for Orani deposits.
Several mines, no more exploited, were distributed in Piedmont (Val di Lanzo), northern Appenines (Taro Valley), Tuscany(Montenero), Calabria (Serra San Bruno) and Sardinia (S'Arenargiu, Nuoro). Domestic industrial uses are in the paper, cosmetic--pharmaceutical, paints, plastics, ceramic and rubber production.
The purpose of this study was to characterize the mineralogical composition of italian talcs from active and inactive mines, giving special attention to the occurrence of asbestiform minerals.
In addition several samples of commercial talcum powders from the market have been investigated for their mineral fibre content because more than 20% of talc used in this country comes from imports of various origin with unknown composition.

Materials and methods

Representative samples from 3 active mines and from 6 inactive mines have been analyzed for their mineral phase composition by x ray diffractometry (XRD), infrared (IR), phase contrast optical(PCDM) and scanning electron (SEM) microscopy techniques.
Analytical procedure followed were those reported in a previous paper (Verdel et al., 1985).
19 commercial, talcum powders have been analyzed by PCOM and dispersion staining methods for identification of the mineral particles using counting and sizing criteria reported in Marconi et al. (1986). In summary, asbestos fibres, identified by dispersion staining method, with diameters in the range $\leq$ 0.3 - 5 μm and aspect ratio $\geq$ 3 : 1 have been considered : chrysotile and tremolite group fibres longer than 5 μm, with diameter less than 0.3 μm have been separately recorded and aspect ratios distribution of fibres in three ranges ($\geq$ 3 : 1 - $<$ 5:1; $\geq$ 5:1 - $<$ 10:1; $\geq$ 10:1) have been reported.

Results and discussion

Tables 1 and 2 show the mineralogical composition of talcs extracted from active and inactive mines, determined by XRD and IR methods.
Samples still in production does not show the presence of serpentine or tremolite amphibole minerals, at least according

to the sensibility of analytical methods used (about 1% w/w). In samples from the inactive mines of Bagnada, tremolite and/ /or serpentine phases were found to be present, in some cases, at considerable levels (up to 15% by weight in the white type).

TABLE 1 - Mean Mineralogical Composition of Talcs from Active Italian Mines (weight %)

Active Mines	Talc	Chlorite	Calcite Dolomite Magnesite	Quartz	Production rate (100 tpa)
Piedmont					
Fontane	90÷95	3÷7	1÷2	tr.	420
Sardinia					
Sa Matta					
- white	90÷95	2÷8	-	-	40
- grey	40÷60	10÷50	2÷8	0÷2	140
Lombardy					
Valtellina	45÷55	20÷35	15÷35	-	690

Tremolite was also detected in the Val di Lanzo samples (5-10% by weight) and in Montenero and S'Arenargiu samples,but at traces levels.
Examination by microscopic techniques of the samples containing serpentine and tremolite minerals has shown, however,

Table 2 - Mean Mineralogical Composition of Talcs from Inactive Italian Deposits (weight %)

Inactive Deposits	Talc	Chlorite	Calcite Dolomite Magnesite	Serpentine	Tremolite	Mica	Quartz	Year of the end of the production
Piedmont								
Val di Lanzo	60÷ 85	5÷ 25	1÷ 5	—	5 ÷ 10	—	1	1983
Lombardy								
Bagnada								
- white	50÷ 70	—	15÷ 50	—	0 ÷ 15	—	0÷ 2	1987
- grey	45÷ 60	5÷ 20	5 ÷ 30	10÷ 20	0 ÷ 5	—	1÷ 3	1987
Emilia								
Val Taro	90÷ 95	0÷ 6	2 ÷ 5	—	—	—	—	1950
Tuscary								
Montenero	30÷ 40	50÷ 60	1 ÷ 10	—	tr.	-	-	1964
Calabria								
Serra S. Bruno	20÷ 40	20÷ 50	—	—	—	20÷ 40	—	1960
Sardinia								
S. Arenargiu	40÷ 60	30÷ 50	—	—	tr.	—	—	1977

that these mineral phases were present mostly with non asbestiform morphology.
In fact they did show a platy habit (antigorite) and prismatic-acicular shape (tremolite as shown in Figure 2.

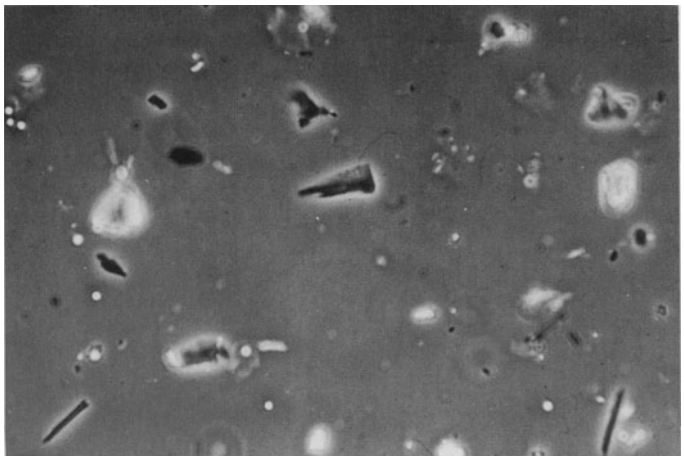

Figure 2 - Prismatic and acicular fragments of tremolite in Val Bagnada samples.

In table 3 are reported the results of the analyses obtained for commercial talcum powders.
Total mineral fibres, asbestos fibres and amphibole (tremolite) fragments (aspect ratio $\lesssim$ 3:1) concentrations, in terms of percentage by number, are included in the table.
In the majority of the samples only a small percentage of the total mineral fibres was found to be asbestos (chrysotile and tremolite) at levels ranging from $\lesssim$ 0.2 to 1.3%. In only one sample, known of chinese origin, asbestos fibre content was 3.2%. Most of the non asbestos fibres were found to be talc by SEM (see Figure 3) or cleavage particles from other

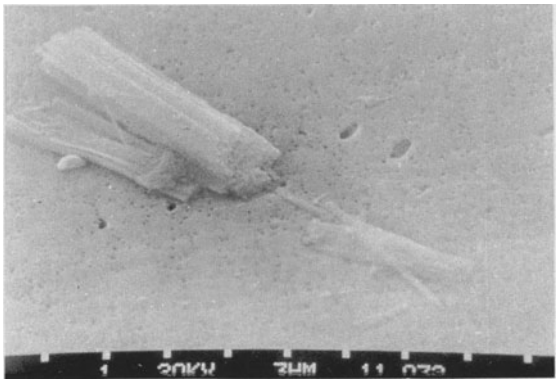

Figure 3 - Bundle of fibrous talc particles.

minerals. In all of the samples a substantial number of amphibole fragments (non fibrous) was found, probably originating from crushing and grinding operations used during the production phases (see also Pang et al., 1987). In general cosmetic powders did show asbestos concentrations more uniform and lower than the other types of powders.
From diameters distribution of amphibole fibres shown in table 4, it appears that most of the fibres have diameters in the range 0.5 - 2.0 μm, with appreciable differences among powders used for various purposes.

Table 3 - Fibre content in samples of italian commercial talcs

Sample	Total fibres (% number)	Asbestos fibres (% number)	Ratio of asbestos fibres to total fibres %	Ratio of amphibole[a] fibres to asbestos fibres %	Percentage amphibole[b] fragments in the total amphibole[c] particles	Ratio of chrysotile fibres to asbestos fibres %
Industrial						
A1	1.7	1.3	76.5	12.0	33.0	88.0
A2	5.6	0.7	12.5	n.d.	100.0	100.0
A3	1.2	n.d.[d]	n.d.	n.d.	100.0	n.d.
A4	1.2	< 0.2	16.5	100.0	90.0	n.d.
A5	2.9	< 0.2	7.0	33.0	70.0	67.0
Pharmaceutical						
B1	7.0	3.2	46.0	100.0	20.0	n.d.
B2	1.3	0.6	46.0	88.0	38.0	12.0
B3	2.4	0.9	37.5	37.0	40.0	63.0
B4	2.0	< 0.2	10.0	100.0	18.0	n.d.
B5	3.7	0.2	5.5	n.d.	100.0	100.0
B6	0.9	< 0.2	20.0	30.0	90.0	70.0
Cosmetic						
C1	2.7	< 0.2	7.5	67.0	60.0	33.0
C2	3.5	0.4	11.0	35.0	45.0	65.0
C3	1.9	0.2	10.5	95.0	45.0	5.0
C4	3.1	< 0.2	6.5	n.d.	100.0	100.0
C5	0.7	0.2	28.5	100.0	30.0	n.d.
C6	2.5	< 0.2	8.0	33.0	90.0	67.0
C7	4.2	0.5	12.0	n.d.	100.0	100.0
C8	3.3	0.5	15.0	100.0	44.0	n.d.

a - The term "amphibole" includes the minerals: tremolite, anthophyllite and actinolite.
b - Fragment means a particle with aspect ratio < 3:1.
c - Amphibole particles means fibres + fragments
d - n.d. = not detected

The differences in fibre size between chrysotile and tremolite fibres present in the samples are evident from size measurements reported in tables 5 and 6, which show the percentage of fibres longer than 5 μm and thinner than 0.3 μm and aspect ratios distribution respectively. Table 4 show that a large amount of chrysotile fibres are long and thin, while there are few amphibole fibres thinner than 0.5 μm. Similar differences exist for aspect ratios of chrysotile fibres, which mostly are ≥ 10:1, while for tremolite fibres aspect ratios fall in the range ≥ 3:1 - < 10:1 as shown in table 5.

Table 4 - Diameters (/um) distribution of amphibole fibres (Percent values)

Sample	0.3	0.31–0.5	0.51–1.0	1.1–2.0	2.1–3.0	3.0
Industrial						
A1	—	—	—	100	—	—
A2	—	—	—	—	—	—
A3	—	—	—	—	—	—
A4	—	—	—	100	—	—
A5	—	—	—	100	—	—
Pharmaceutical						
B1	—	18	35	41	—	6
B2	—	—	69	31	—	—
B3	—	15	62	12	11	—
B4	—	—	53	37	10	—
B5	—	—	—	—	—	—
B6	—	—	—	50	50	—
Cosmetic						
C1	—	—	—	100	—	—
C2	—	17	17	36	15	15
C3	16	16	26	32	10	—
C4	—	—	—	—	—	—
C5	7	21	47	18	7	—
C6	—	—	50	—	—	50
C7	—	—	—	—	—	—
C8	5	21	21	37	11	5

* Hyphen indicates the absence of fibres with the stated diameter.

Table 5 - Percentage of fibres with $L \geq 5$ /um and $D \leq 0.3$ /um

Sample	$L \geq 5$ /um		$D \leq 0.3$ /um	
	Chrysotile	Amphibole	Chrysotile	Amphibole
Industrial				
A1	90	90	29	—*
A2	> 95	n.d.	75	n.d.
A3	n.d.**	n.d.	n.d.	n.d.
A4	n.d.	≥ 95	n.d.	—
A5	> 95	> 95	> 95	—
Pharmaceutical				
B1	n.d.	53	n.d.	—
B2	33	90	—	—
B3	> 95	78	33	—
B4	n.d.	74	n.d.	—
B5	> 95	n.d.	—	n.d.
B6	> 95	> 95	60	—
Cosmetic				
C1	> 95	> 95	> 95	—
C2	> 95	> 95	18	—
C3	> 95	80	> 95	16
C4	> 95	n.d.	17	n.d.
C5	n.d.	68	n.d.	7
C6	> 95	50	50	—
C7	> 95	n.d.	33	n.d.
C8	n.d.	68	n.d.	5

* Hyphen indicates the absence of fibres with the stated dimension
** n.d. means the absence of asbestos fibres of the stated type.

Conclusions

Results obtained from tha samples investigated have shown that asbestiform phases content of talcs mined today in Italy is very low. Inactive mines deposits in some case contained substantial amount of serpentine and amphibole minerals, but their predominant morphology appears to be platy and prismatic or acicular respectively.

In commercial talcum powders asbestos fibres are present at levels mostly less than 1% (by number) and likely less than 1% by weight (Marconi et al., 1986). Amphibole (tremolite) fibres occuring in these powders, however, do show sizes more consistent with prismatic, than with asbestiform shape (Campbell et al. 1979; Marconi et al., 1986).

Nevertheless, because substantial amount of talc for domestic consumption still comes from imports of various origin, China included (Verdel et al., 1985), it cannot be excluded that asbestos contamination might occur in some cases.

For these reasons it appears necessary to continue investigations to carefully control the presence of asbestiform fibres, especially in talcum powder products, which have a large use among consumers.

Table 6 - Aspect ratios distribution for asbestos fibres (percent values)

	Chrysotile			Amphibole		
Sample	≥3:1-<5:1	≥5:1-<10:1	≥10:1	≥3:1-<5:1	≥5:1-<10:1	≥10:1
Industrial						
A1	7	36	57	—*	100	—
A2	—	—	100	—	—	—
A3	—	—	—	—	—	—
A4	—	—	—	100	—	—
A5	—	<5	>95	100	—	—
Pharmaceutical						
B1	—	—	—	35	47	18
B2	—	67	33	19	69	12
B3	—	—	100	33	45	22
B4	—	—	—	37	53	10
B5	—	—	100	—	—	—
B6	—	—	100	100	—	—
Cosmetic						
C1	—	—	100	50	50	—
C2	—	—	100	17	50	33
C3	—	—	100	21	42	37
C4	—	—	100	—	—	—
C5	—	—	—	25	61	14
C6	—	—	100	100	—	—
C7	—	—	100	—	—	—
C8	—	—	—	32	58	10

* Hyphen indicates the absence of fibres with the stated aspect ratio.

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Exhibit 18

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEW JERSEY

IN RE: JOHNSON & JOHNSON TALCUM POWDER PRODUCTS MARKETING, SALES PRACTICES AND PRODUCTS LIABILITY LITIGATION	MDL NO. 16-2738(FLW)(LHG)
THIS DOCUMENT RELATES TO ALL CASES	

PURSUANT TO NOTICE, the 30(b)(6) deposition of IMERYS TALC AMERICA, INC., through the testimony of PATRICK DOWNEY, was taken on behalf of the Plaintiffs at Gordon & Rees, 555 Seventeenth Street, Suite 3400, Denver, Colorado, on August 7, 2018, commencing at 9:36 a.m., before Melanie L. Giamarco, Registered Professional Reporter, Certified Realtime Reporter, and Notary Public within Colorado.

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I N D E X

(Cont'd)

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P R O C E E D I N G S

(Exhibits 1 and 2 were marked for identification.)

VIDEOGRAPHER: We are now on the record. My name is Joel Coriat. I am the videographer, representing Golkow Litigation Services. The date today is August 7, 2018. The time is now 9:36 a.m.

This video deposition is being held in Denver, Colorado, in the matter of Johnson & Johnson talcum-powder products Marketing, Sales Practices and Products Liability Litigation for the U.S. District Court, District of New Jersey. The deponent is Pat Downey. Counsel will be noted on the stenographic record.

The court reporter is Melanie Giamarco. She will now swear in the witness.

PATRICK DOWNEY,

after having been duly sworn, was examined and testified as follows:

EXAMINATION

BY MS. O'DELL:

Q. Good morning, Mr. Downey.

A. Good morning.

Q. My name is Leigh O'Dell. We met just a few minutes ago. And I'm here on behalf of the Plaintiffs' Steering Committee on behalf of more than 9,000 women who have filed claims who have ovarian cancer, either suffering or died of ovarian cancer. And I'm here to ask you questions today on behalf of Imerys.

Do you understand that?

A. Yes.

Q. Okay. Let me show you what I've marked prior to the deposition as, first, Exhibit 1, which is the deposition notice, and Exhibit 2, which is an e-mail from counsel for Imerys.

Have you seen this document before, Mr. Downey?

A. Yes.

Q. And as I understand it, today you have come to provide testimony on the topics listed in the notice as amended by the e-mail from counsel, I believe, on July 31st, correct?

A. Yes.

Q. And those topics include the talc mines, the identity of the talc mines that were sources of talc for Johnson & Johnson talcum-powder products, which was in the notice, Roman numeral I, Topic 2; do you see that, sir?

A. Yes.

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Q. Great. You're also here to provide testimony for Roman numeral I, subsection 8, which is processing of talc by Imerys --

A. Yes.

Q. -- correct?

A. Mm-hmm.

Q. You're here today as well to, or tomorrow -- to talk about subsection Roman numeral II, 9, which relates to quality assurance?

A. Yes.

Q. And then lastly, you're here to offer testimony on behalf of Imerys for the topics Roman numeral III, 1, which relates to sampling, and 2, which relates to the process or handling of samples, correct?

MR. PROST: And 6.

MS. O'DELL: Yes. Thanks, Mark.

Q. (By Ms. O'Dell) And Number 6, protocols or restrictions on mining talc for use in talcum-powder products?

A. Yes, those three.

MR. PROST: And just one small clarification, you'll see in the e-mail, with respect to section Roman numeral III, 1 and 2, there's sentence in there clarifying that Pat is

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designated on these topics for any part of the sampling process that occurs prior to the receipt of the samples by the analytical lab in San Jose, California, with Julie Pier remaining designated as to those topics for questions relating to the testing of samples which occurs at the analytical lab at the request of the analytical group.

Q. (By Ms. O'Dell) Mr. Downey, Imerys Talc America is the name --

A. Can you speak up a little? I'm hard of hearing.

Q. Yeah, sure.

Imerys Talc America is the defendant in this litigation. Imerys has had numerous predecessor companies, including Rio Tinto Minerals.

Are you aware of that, I'm sure?

MR. PROST: I'm going to object to form. I think it's inaccurate saying it's a predecessor company.

MS. O'DELL: Okay.

Q. (By Ms. O'Dell) Well, let me just ask you today --

MR. PROST: And actually, Leigh, before we go any further, I just wanted to make one more housekeeping item.

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MS. O'DELL: Oh, sure.

MR. PROST: If I could make this as an exhibit. This is a June 22, 2018, letter by Mr. Silver just memorializing the agreement that Imerys made with the Plaintiffs' Steering Committee as to objections to certain definitions in the 30(b)(6) notice. And we'll mark this as Exhibit 3 Downey.

(Exhibit 3 was marked for identification.)

MR. PROST: And I'll just say that the objections are definitions number 7, 8, 9, 11 and 12. We have a standing objection to those definitions and we won't need to repeat those throughout the deposition as those terms come up.

MS. O'DELL: Yeah. The Plaintiffs' Steering Committee is aware of the objection and, obviously, notes them for the record, but disagrees, and so we're not bound by those objections as we ask questions about, for example, the definition of "asbestos" and other things going forward to the deposition today.

Q. (By Ms. O'Dell) Mr. Downey, I was asking you about the companies that have been associated or preceded Imerys Talc America. And I want to have an understanding today as we go

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through this deposition when we're talking about documents that may have arisen during a time period, for example, when the company name was Luzenac or relates to Rio Tinto Minerals. I want us to have an agreement that when I ask you a question about those documents and I refer to "Imerys," you are binding Imerys as a company in relation to those topics.

Do we have an agreement?

MR. PROST: Object to form.

A. I'm not sure I understand quite what you mean by binding those entities. I'm aware of the history of the company, and, you know, I'm aware of Luzenac America and Rio Tinto Minerals, you know, in the context of the historic -- historically related parties, so I'm not sure what you mean by bound.

Q. (By Ms. O'Dell) Okay. Well, we'll go through it step by step as we go through the deposition, but at least let's see if we can get this agreement.

When I refer to "Imerys," we have an agreement that that encompasses Luzenac and Rio Tinto?

A. "Encompasses"? I think I can agree to

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that.

Q. Okay. Fair enough.

We're taking your deposition here today for purposes of general causation only. The Court in the MDL -- you may or may not be aware, but I need to say this for the record -- has limited the scope of your deposition as a corporate representative of Imerys to topics that relate to the general-causation aspect of the plaintiffs' case. So we reserve the right to redepose you as an individual or on behalf of the corporation when it comes to the time period where liability depositions are going forward. And that may or may not make sense to you, but I need to say that for the record.

A. Okay.

Q. Second, I would say on Friday afternoon, very late in the day after 5:00, at least 5 p.m. Central time, we received a production from Imerys that encompassed more than 1,600 documents. About a third or more of those involved the topics that you're providing testimony on.

MS. O'DELL: So I said I was going to put this on the record, Counsel, so I'll do it right now.

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Those were made available to us late by an FTP link. It wasn't until Monday morning that we were able to get access to those documents on our review platform. We're working through those, but we reserve the right to have additional time, other than the two days set aside this week to depose Mr. Downey on the documents that were produced to us.

MR. SILVER: Your objection's noted. We will -- we don't agree, but we can -- as always, we'll meet and confer and talk about it, if necessary.

MS. O'DELL: Fair enough.

Q. (By Ms. O'Dell) Mr. Downey, I want to talk to you a bit about your background first. And I'm going to hand to you a copy of a curriculum vitae that was provided to us by your counsel. I've marked it as Exhibit 4.

(Exhibit 4 was marked for identification.)

MS. O'DELL: Guys, I'm short a copy. I apologize.

Q. (By Ms. O'Dell) Mr. Downey, did you prepare this curriculum vitae?

A. Yes.

Q. And when did you prepare it? Was it

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prepared for purposes of this deposition?

A. It was updated. I mean, I think I updated it about a year ago, and then I reviewed it when it was provided.

Q. And I'm not going to spend a lot of time on this, but I just want to ask you a couple of preliminary questions, and then we'll come back to this.

Is it fair to say that during your tenure with Imerys that you have not had any responsibility or managerial responsibility for the operation of Imerys' talc mines in Vermont?

A. That's correct.

Q. And is it also fair to say that in your tenure as an employee of Imerys, or one of the previous predecessor companies, that you've had no role in supervising or managing the processing plant at West Windsor?

A. That's correct.

Q. And is it also fair to say that you've not had a supervisory role, managerial role or any input into the operations of the Houston processing plant?

A. That's correct.

Q. In regard to the mining operations in

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China, is it fair to say that you have not been involved in the oversight of the mining operations that have resulted in talc being sold to Johnson & Johnson?

A. That's correct.

Q. Mr. Downey, in the Notice of Deposition, there is a section called "Instructions." I don't know if you've had an opportunity to take a look at that. It's on page 10 of the notice. Gives some ground rules, if you will, about what I can ask you in regard to your preparation for your testimony here today.

You've provided a curriculum vitae. I thank you for that. But I also want to know what you did to prepare for your deposition. And so let me begin by asking when you learned that you would serve as a corporate representative in this context.

A. I believe sometime in May or June, I think.

Q. Since that time, how many times -- let's say it was the end of May. Let's put it in that context; does that sound fair?

A. Fair.

Q. Since May, how many times have you met

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with counsel to prepare for your testimony today?

A. On, I think, four occasions.

Q. When was the first time that you met with Imerys' counsel?

A. Mid- to late June, I think.

Q. And do you have a specific date when you met with counsel?

A. Not that I recall, no.

Q. Did you make any notes during that meeting?

A. I've made some notes. And I believe they've been provided.

Q. Counsel did provide a group of handwritten notes to us. I'm going to mark that right now as Exhibit 5.

(Exhibit 5 was marked for identification.)

Q. (By Ms. O'Dell) Are those the notes that you're referring to?

A. Yes.

Q. Mr. Downey, are these notes provided in chronological order? Some of them are not dated. I'm just trying to get a sense of when you had certain meetings and certain discussions.

A. I'm not sure that they're in chronological order. There are some general notes

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that I think are out of order.
Q. How did these notes come into existence? Are these your notes, your handwritten notes?
A. Yes, they are.
Q. Were these taken contemporaneously with the discussion that you were having? In other words, were they rewritten or are these the notes you took during particular meetings or calls?
A. They were contemporaneous.
Q. The first page of Exhibit 5 appears to be -- let me -- why don't you tell me what it is?
A. It's the -- I made a note in my calendar for a call with Miss Pier Julie Pier, another witness who's going to be deposed in this matter.
Q. And the date of this call, according to your calendar, is July 27th, 2018?
A. Yes, ma'am.
Q. How many times had you met with counsel prior to having this discussion with Miss Pier -- is it Peer or Pier?
A. What you just said, I didn't distinguish a difference. It sounded like "Peer" to me.
Q. All right. It's a little hard to understand my southern accent sometimes, too, so we'll see.

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But -- okay. Miss Pier, you talked with her on July 27th.
My question is, how many times had you met with counsel prior to this discussion with Miss Pier?
A. I'd say at least twice. I don't recall the specific dates of the meetings, but Friday, July 27th, was only a few weeks ago.
Q. So you met with counsel at least twice prior to that time.
Were those -- was the first meeting in person?
A. Yes.
Q. Where did you meet?
A. In Bozeman, Montana.
Q. Who did you meet with? Who was present?
A. Jim Robinson with Gordon & Rees was present with me. There was other counsel on the phone, including Mark Prost, Andrew Cary. Oh, and Dave Marek.
Q. Who is Dave Marek?
A. He's a geologist.
Q. And what's -- is he an employee of Imerys?
A. He's an Imerys employee. I'm not sure

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which company.
Q. And when you say "which company," which companies are you referring to? Imerys Talc America and what other entity?
A. Perhaps Imerys Talc Canada.
Q. And what is -- is it Mr. Herrick?
A. Marek. M-a-r-e-k.
Q. And what is -- in terms of Mr. Marek's role, you said he's a geologist.
What's his area of responsibility?
A. The ore reserves and mine-planning aspects of our talc mines.
Q. For all Imerys talc mines?
A. I'm not sure how expansive his scope is, but generally, North America.
Q. Does Mr. Marek have any responsibility for operations or -- strike that.
Does Mr. Marek have responsibility that relates to the mining operations in China?
A. No, I don't think so.
Q. Did he provide you with information regarding the mining operations in China?
A. Not China, no.
Q. Was anybody else present in person physically at the meeting other than those you've

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described?
A. The only two -- the only person present with me, again, was Jim Robinson. The others were on the phone.
MS. O'DELL: And I don't know Mr. Robinson, but I believe he is counsel for Imerys; is that correct?
MR. SILVER: Yes.
MR. PROST: Yes.
Q. (By Ms. O'Dell) And in terms of counsel on the phone, who participated by telephone?
A. As I said, Mr. Prost and Andrew Cary.
Q. How long did the meeting last?
A. I think maybe four hours or so. It's been a while. And I have had subsequent meetings with counsel. It's kind of running together, the time frames.
Q. Other than -- were there any other Imerys employees on the telephone besides Mr. Marek?
A. No.
Q. What was the purpose for having Mr. Marek on the phone call?
A. He had information about the geology and mine-planning of the Argonaut Mine in Vermont.

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Q. You've been an employee of Imerys, or Luzenac, previously, since 1994, I believe?
A. No. 1998.
Q. '98, okay.
And do you have an understanding as to how long Mr. Marek has been employed by Imerys?
A. I don't know when he began, so I -- I don't know.
Q. Was it before you started with the company?
A. No. I believe it was after I started.
Q. Without having a specific year in mind, do you have a general understanding? Has he been an employee more than ten years, for example, to your knowledge?
A. Yes, more than ten.
Q. Used to, ten years ago, it seemed like it wasn't -- it was a long time, but that only puts us at 2008.
Let me ask. Was Mr. Marek a geologist with Imerys during the time period that the Vermont mines sourced talc for J&J?
A. Perhaps at the very end.
Q. And that would put us at 2002 or so?
A. 2003.

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Q. And so as I understand it, that was your first meeting with counsel -- your first meeting in person with counsel; is that fair?
A. That's my recollection, yes.
Q. Prior to that meeting, how many telephone calls had you had with counsel for Imerys?
A. I think one, just to let me know that I had been designated for certain topics. And we just discussed the logistics of how I needed to be -- come prepared --
MR. PROST: Pat, obviously, don't share any communications with counsel that are protected by attorney-client privilege. I think you've said enough.
Q. (By Ms. O'Dell) Were you provided documents to review in order to prepare for your deposition?
A. Yes. I received some documents.
Q. Did you receive them electronically or in hard copy?
A. I think the majority of them electronically.
Q. Approximately how many documents were you provided for your preparation?

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A. I don't have a specific number.
Q. Can you give me an estimate?
A. Not really, no.
Q. Was it more than 50?
A. Probably, yeah.
Q. Was it more than 75?
A. I'd say so. More than a hundred.
Q. Well, it seems like you've got some idea of how many there were.
So can you estimate for me? Generally speaking, how many documents were you provided?
A. I don't think I could estimate accurately anything more than a hundred. And those were the ones that -- there were a number of documents that I received. Some of them were, you know, types of information, and I only up -- you know, looked at examples of some. So I didn't count them all, so I don't really have an estimate.
Q. When did you receive those documents?
A. Early July.
Q. And were they provided basically all at one time?
A. I think most of them, yes.
Q. Were they sent to you by counsel or an employee of Imerys?

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A. Mr. Marek sent me . . .
Q. Did you undertake to go through the database or files at Imerys in order to educate yourself for your deposition today?
A. I'm not sure what you mean by "database."
Q. Let's see.
Did you -- I mean, you're an employee of Imerys, correct?
A. Yes, I am.
Q. And as an employee and in your specific title -- didn't put that on your record.
Your specific title at this point is director of NPD engineering?
A. That's right.
Q. So what does NPD --
A. New product development.
Q. And, you know, in your role as an employee of Imerys, did you look through common databases of documents or information in order to educate yourself for your deposition?
A. Yes. Some of our quality protocols are on the SharePoint system.
Q. And first, why did you decide to search for these quality protocols for your deposition

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today?
A. Because they were listed amongst the topics that I had been designated for.
Q. Is -- were they protocols that you would normally have familiarity with or employ in your role as director of NPD Engineering?
A. In some cases, I would refer to those documents.
Q. But that -- quality assurance is not your primary responsibility, correct?
A. No.
Q. And in terms of the protocols that you searched out, could you reference them either by topic for me, or number?
A. I reviewed some of the quality protocols for our Houston facility, things about how we sample -- or how we control the receipt of shipments of ore from China, how we take a sample of it, how it's processed at the mill, how it's quarantined and how those samples are then passed on to our analytical group for analyses, things like that.
Q. Did you print out copies of those protocols?
A. Yes.

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MS. O'DELL: I would -- Mr. Downey searched those out on his own. They were not provided to him by counsel. I don't think the attorney-client privilege applies. So we would ask for copies of whatever he pulled down from the SharePoint files in order to get a sense of what those were.
MR. PROST: We'll discuss it on the break.
Q. (By Ms. O'Dell) Mr. Downey, we talked about the first meeting you had in person at Bozeman, Montana. You mentioned there was two meetings before you actually had a phone call with Miss Pier.
So when was the second meeting?
A. Some -- it was before we met with Miss Pier. I don't recall a specific date. I'm sorry.
Q. Was it in July?
A. I believe so.
Q. Where did the meeting take place?
A. In Bozeman.
Q. At your office in Bozeman?
A. No.
Q. Where?
A. At a hotel.
Q. Who was present?

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A. Mr. Cary, Mr. Prost and Mr. Robinson.
Q. Anybody participate by telephone?
A. I don't recall. I don't think so.
Q. How long did the meeting last?
A. We met for a day and a half.
Q. Did you review documents during that meeting?
A. More than likely. I don't recall the specific meeting.
Q. Did you have any other phone calls during July regarding your testimony -- let me start again, just to make it clear. Sorry.
You had a phone call with Miss Pier on July 27th?
A. Yes.
Q. Did you have any other phone calls with Imerys employees during the month of July?
A. I think the call with Dave Marek was in early July. I think I already mentioned that.
Q. Yeah. Thank you. Your answer was better than my question. Sorry.
You'd been deposed a number of times, Mr. Downey, so I didn't go through the ground rules, but if I do ask you a bad question, you don't understand it, just let me know, and I'd be

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happy to rephrase it.
Okay. Let's move our attention back to the notes that you provided that, for the record, have been marked as Exhibit 5. You had a call with Miss Pier, Julie Pier, on July 27th.
Who set up this call?
A. Andrew Cary, I believe.
Q. Who was on the phone call besides yourself and Miss Pier?
A. Counsel, I believe Andrew Carry, Mr. Prost and Mr. Robinson.
Q. How long did the call last?
A. I think it was an hour.
Q. And if you'll turn to page 2 of Exhibit 5, are those notes from the call with Miss Pier?
A. On page 2?
Q. Yes.
A. Yes.
Q. And actually, page 3 also has a notation "J.P."
Does that stand for Miss Pier Julie Pier?
A. Yes, it does.
Q. And you note on page 2 of the exhibit that blast holes -- what did you discuss with

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Miss Pier regarding blast holes?
A. We discussed some of the testing of the blast holes. If the lab at the mine had detected amphibole, then a sample of the blast hole would be forwarded to Julie for further analysis.
Q. And then was the discussion of blast holes primarily focused on Vermont?
A. Yes, ma'am.
Q. Did you have any discussion of the drilling or blasting that was done in China?
A. No, not with Miss Pier.
Q. Following the notes here, you have "serpentine," I believe it's at least part of that, but I can't read your writing. Sorry. What is that?
A. Serpentinite.
Q. Serpentinite.
What was your discussion with Miss Pier regarding serpentinite?
A. She had also mentioned that they characterized the serpentinite core, specifically looking for asbestos minerals, and found none. They also tested a variety of waste-hole samples that covered the serpentinite, again looking specifically for asbestos minerals and found none.

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Q. And during -- you note these are aggregate tests on the side.
What time period did this testing take place?
A. I don't recall if she mentioned the time frame. You can ask her.
Q. Happy to do that. And we will ask her.
But in terms of the specific results she's referring to, did she put any time parameters on that discussion?
A. Not that I recall.
Q. Did you review any documents over the phone with Miss Pier?
A. No.
Q. On page 2 of your notes from your call, it references China. And what was your discussion with Miss Pier about China?
A. Well, we don't control the mine in China, but I know that it's a topic that I had been designated for, so I asked Julie if she -- you know, if she could tell me what she knew about China. And these were the notes that I took about that.
Q. And you've never been to the mines in China, true?

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A. That's true. I have not.
Q. And to your knowledge, has Miss Pier ever visited the mines in China?
A. I don't know.
Q. Other than the three sort of larger topics that we've talked about -- blast holes, serpentinite and China -- were there any other topics that you discussed with Miss Pier?
A. I think we discussed the general overall topics and how there was potential overlap between topics that she was designated for and I was designated for and where the -- where the cut-off, so to speak, would be.
Q. And was it during this discussion that the decision was made not to designate you as a witness for Topic I, subsection 1, which relates to the composition of the talcum-powder products?
A. I think it was discussed at that time. I don't know that the final decision was made at that phone call.
Q. Let me ask you to turn to the next page of this exhibit. And they're not numbered, so we just have to follow along together and make sure we stay on the same page. But it appears to be notes from an 8/1 discussion. And that would be

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August the 1st?
A. Yes.
Q. And who is "Des. G"?
A. Desiree Giroux.
Q. I'll need a little help with that spelling.
A. I'll try my best. G-i-r-o-u-x.
Q. And the first name is Desiree?
A. Desiree.
Q. Desiree. So is that D-e-s-i-r --
A. i-r-e-e.
Q. i-r-e-e, okay.
Who is Miss Pier Giroux?
A. She is an employee at the Vermont talc mine, and she handles the quality program there now.
Q. Did you talk with Miss Pier Giroux by telephone?
A. Yes.
Q. How long was your phone call?
A. Maybe 15, 20 minutes.
Q. And what was the purpose of your discussion with Miss Pier Giroux?
A. To discuss the testing protocol for production and from blast holes of the Vermont

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mine.
Q. Who else was on the phone besides yourself and Miss Pier Giroux?
A. No one else.
Q. And do you know her title?
A. I think it's HSEQ manager. HSEQ, health, safety, environment, quality.
Q. And do you know how long she's held that position at the Vermont mines?
A. Maybe four or five years. I'm not sure.
Q. Was Miss Pier Giroux employed by Imerys and working at the Vermont mines during the time period that Vermont was sourcing talc to -- for Johnson & Johnson Baby Powder?
A. I don't know when she hired on with us, but I believe it was after that period.
Q. So to be clear, Miss Pier Giroux is the health and safety and quality manager --
A. Currently.
Q. -- currently, but she was not responsible for quality assurance during the time period when talc was being sourced for Johnson & Johnson talcum-powder products, true?
A. That's true.
Q. According to your notes here,

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Miss Pier Giroux expressed to you that daily product composites are made by mill operators, and then it says, "from in-process samples analyzed by XRD." And then what's the next?
A. Leco, L-e-c-o.
Q. "...to determine daily," and I assume that's "mineralogy"?
A. That's right.
Q. Do you have an understanding from Miss Pier Giroux how long that, approximately, was in place?
A. It predates her. My understanding is that it goes back -- I think it was consistent with the time period -- it was a program that was in place when Cyprus purchased Windsor Minerals in 1989.
Q. What do you base that understanding on?
A. I also had a phone call with Robin Reilly, and she told me what happened from, like, 1998 going forward. And her description lined up with what Miss Pier Giroux said.
And I've also seen documents of the protocol that was in place in 1989. So they're consistent with one another.
Q. When did you talk with Miss Pier Reilly?

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Robin Reilly, correct?
A. Yeah. Actually, in fact, that was in person. It was last Friday or Saturday.
Q. Friday ten days ago, or just a few days ago?
A. Just a few days ago.
Q. So that would have been August the 1st or 2nd?
MR. PROST: 3rd.
MS. O'DELL: 3rd. Oh, sorry. 3rd.
Q. (By Ms. O'Dell) How did you come to meet with Miss Pier Reilly?
A. She was in Montana.
Q. And does she work in Montana?
A. Pardon?
Q. Is she an employee of Imerys Montana?
A. No. She still works out of Vermont, but she was out in Montana on business.
Q. Okay. Was the purpose of Miss Pier Reilly's trip to Montana to meet with you for purposes of preparing for your deposition?
A. No.
Q. What's her position presently?
A. She handles land management and reclamation activities and permitting activities.

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Q. At Vermont?
A. At Vermont, yes.
Q. And did -- has Miss Pier Reilly had responsibility for sampling and quality assurance at Vermont?
A. From 1998, when she hired on, for a few, maybe several years, she worked in the QA lab at the local facility.
Q. Was she a technician in the lab?
A. I know she did lab analyses. I don't know if -- what her title was at that period.
Q. What's her educational background?
A. I'm not sure.
Q. As a person who was in the lab doing analyses, whatever -- well, let me ask you.
Do you know what type of analyses that she was tasked to perform during that time period?
A. She did XRD, Leco anatomic absorption analyses.
Q. And the --
A. Perhaps others. Those were ones we discussed.
Q. And for that time period, her responsibility focused on performing analyses in the lab. It was not -- she was not involved in

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actually taking samples, correct?
A. I'm not sure what you're asking.
Q. Let's see if I can be more clear.
Her responsibilities related to performing analyses on samples when they came to the lab, true?
A. Generally speaking, yes, but I can't say whether or not she also had to go take samples. I don't know. I didn't ask her that.
Q. You don't know, one way or the other?
A. No.
Q. Did you reach out to Miss Pier Reilly or did someone else facilitate the meeting with her?
A. I reached out to her.
Q. How long was your discussion with Miss Pier Reilly?
A. Ten minutes, I think.
Q. Let me ask you to turn the page in the exhibit, Mr. Downey, and there are some notes that are titled "8/1 phone call with D. Crouse and counsel." And it says 7 to 9 a.m.
Is that the length of the call with Mr. Crouse and counsel?
A. Yes.
Q. And who is D. Crouse?

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A. David Crouse.
Q. And is he an employee of Imerys?
A. He's a former employee.
Q. And what was his role as a former employee?
A. He had a number of roles, but he's a geologist, so he's done exploration geology, mine planning, ore control, a lot of things related to the ores in the talc mines that we have.
Q. Was Mr. Crouse ever charged with responsibility for mining process in Vermont?
A. Yes, ma'am.
Q. And what was his responsibility?
A. The ore reserves of the deposit, the development aspects of it and also ore-control measures.
Q. And during what time period was Mr. Crouse involved with the talc mines in Vermont?
A. In the late 1990s and early 2000s.
Q. And so his involvement, just to make sure I understood what you were saying -- he had responsibility in relation to Vermont talc mines from the late '90s to early 2000s, fair?
A. That's my recollection.
Q. What did you discuss with Mr. Crouse?

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A. There are several pages of notes here. We discussed the general nature -- the general geology of the talc deposit at Argonaut, and he explained to me in pretty good detail about the metamorphic processes about the deposits and why there are geologic reasons for the absence of chrysotile with respect to that deposit.
Q. Is it your testimony that there is no chrysotile in the Argonaut Mine?
A. That's correct.
Q. And other than your phone call with Mr. Crouse, what do you base that statement on?
A. Mr. Crouse also gave two depositions, and he gave descriptions in those depositions of that as well as his bases for making that -- or making those statements.
Q. Did you review those depositions prior to your testimony today?
A. Yes, I did.
Q. While I'm on the subject, did you review any other depositions of any witness in the talcum-powder litigation in preparation for your deposition?
A. No.
Q. Did you review Miss Pier's depositions

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or trial testimony prior to your deposition?
A. No.
Q. Did you review your own testimony from either trial or deposition prior to the testimony today?
A. No.
Q. You said Mr. Crouse is a former employee of Imerys?
A. Yes.
Q. What's he doing now?
A. He works for a different minerals company.
Q. And what's the name of that company?
A. I believe it's Omya, O-m-y-a.
Q. Does Mr. Crouse reside in Vermont?
A. No.
Q. Where does he reside?
A. In Ohio, I believe.
Q. And I didn't ask you this.
Who, other than yourself and Mr. Crouse, was on the telephone call?
A. Counsel.
Q. Who?
A. Mr. Cary, Prost, Robinson, I believe Sarah O'Donahue from Alston & Bird, and Rodrigo

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Salas from Alston & Bird, also.
Q. Let me ask you to turn over what appears to be the third page of your notes with -- from your phone call with Mr. Crouse.
It says "amphibole" at the top of the page; do you see that?
A. Yes.
Q. And in relation to your conversation with Mr. Crouse, you mentioned you discussed the Argonaut Mine.
Was the primary focus of your conversation the Argonaut mineral deposit and mine?
A. We also discussed China as well, but we probably spent more time on Argonaut.
Q. Did you discuss any of the other mines or deposits that Imerys owns in Vermont?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) Such as Hammondsville, Hamm, Rainbow, Black Bear, or any of the other mines?
A. I believe I asked Dave if he knew about those deposits. My recollection is is that he hadn't visited those during his time period. They were already -- had been phased out. That's my general recollection.

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Q. Now, in the middle of the page, Mr. Downey says "Argonaut"; do you see that in the middle of the page?
A. Yes.
Q. And it has a word I can't read. What does that say?
A. "Dunitic."
Q. "Argonaut dunitic serpentinite was altered from the outside toward the inter (sic) core"; did I read that correctly?
A. "Inner core." Yes.
Q. "Worked from west towards the east where we see the remnants of the dunitic serpentinite," and then there's a word cut off there.
A. "Core."
Q. "Core."
You say, "Can be a transitional zone, narrow, where the serpentinite is not completely altered to talc magnesite"; did I read that correctly?
A. Yes.
Q. And would you agree with me, Mr. Downey, that those areas of transition where, by pressure and heat, there's been a metamorphosis where the alteration is not complete, that that transitional

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fiber can be fibrous, true?
MR. PROST: Object to form.
A. I disagree.
Q. (By Ms. O'Dell) If other geologists who were working in Argonaut wrote contemporaneous notes supporting the conclusion that transitional fibers -- transitional minerals can be fibrous, would you disagree with that?
MR. PROST: Object to form.
A. I'd have to see a document, if you're saying that that was said, but I would disagree with that.
Q. (By Ms. O'Dell) I made a little chart here in your notes. And let me see if I can operate this effectively.
I said "fibrous," then I put "disagree." That's your statement to me, right? You don't believe transitional fibers can be fibrous?
MR. PROST: Object to form.
A. In this transitional zone where I've made notes, there's nothing to do with fibers there. That's the serpentinite. It's not fibrous.
Q. (By Ms. O'Dell) And you're basing that on your discussion with Mr. Crouse?
A. Yes, as well as the evidence of what we

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know about the serpentinite. It's a bladed habit, but it's not fibrous.
Q. We'll get to that.
You made a chart here about asbestiform fibers; do you see that? And let's just see if we can agree on terminology today. You have "serpentine"; do you see that? And then you have as an asbestos variety.
Chrysotile is an asbestos-form serpentine mineral, true?
A. Chrysotile is the asbestos variety of serpentine, but serpentine itself is nonasbestos.
Q. But serpentine can be asbestos, true?
A. No. Chrysotile is asbestos.
Q. Well, chrysotile is a subset of serpentine generally. It's just a fibrous form of serpentine, true?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) True?
A. The serpentinite at Argonaut, as I recall, I think, is the mineral lizardite. I think that's what it's called. And that is nonasbestos. Chrysotile is the asbestos variety of serpentine.
Q. And your testimony is that chrysotile has never been found at Argonaut?

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A. That's correct.
Q. And then you go further and you talk about amphiboles; do you see that?
A. Yes.
Q. And then you say "nonasbestos" in your chart.
You take the position that tremolite is nonasbestos -- is a nonasbestos amphibole?
A. What this chart was, for me, is of these -- of the six asbestos minerals, most of them are amphiboles, but then you also have the serpentine group. And so it's just a sample chart that shows the nonasbestos varieties and then also lists the asbestos varieties.
Q. And so --
A. That's all I was doing here.
Q. Okay. And so you would agree, just to make sure I'm reading your chart right, tremolite can be asbestos?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) It's on your chart here.
A. When described as tremolite asbestos, it would be asbestos, but just because you have the mineral tremolite, that doesn't mean that every

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time you see the word "tremolite" that you're talking about asbestos.
Q. It also doesn't mean it's not asbestos, true?
MR. PROST: Object to form.
A. In what context?
Q. (By Ms. O'Dell) If it says "tremolite" -- "tremolite" only, you can't always assume that that means it's a non-asbestiform-type of tremolite, true?
MR. PROST: Object to form; outside the scope.
A. It would depend on the context of what's written.
Q. (By Ms. O'Dell) Okay. So --
A. I'm not going to -- this is merely a list of minerals.
Q. Okay. Well, and I'm working through it with you, because I want to know what your understanding is, part of us being able to work through the documents we're going to go through later.
Would you agree that tremolite -- excuse me -- strike that.
Would you agree that actinolite can also

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occur in an asbestiform variety?
A. When identified as actinolite asbestos, I would agree that it's asbestos.
Q. And it's your position -- you're taking this on behalf of the company -- that if it just refers to actinolite, then it's not asbestiform?
MR. PROST: Object to form; outside the scope.
A. Again, it depends on the context.
Q. (By Ms. O'Dell) Anthophyllite is also considered to be an asbestos variety, true?
A. Again, when identified mineralogically as anthophyllite asbestos, that's when it's asbestos.
Q. And it's your position, if it doesn't have asbestos anthophyllite, then it's not an asbestiform type, true?
MR. PROST: Object to form.
A. Again, it depends on the context of whatever's written, what it's written about, as well as time frame.
Q. (By Ms. O'Dell) What do you mean by time frame?
A. Mineralogically, since the 1970s and 1980s, 1990s, there's great confusion about the

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actual identification of the asbestos varieties of the minerals.
Q. Okay. If you'll turn on the next page, is this a continuation of your notes from your discussion with Mr. Crouse?
A. Yes.
Q. And you're discussing specifically ore for J&J. And your first note is related to the West Windsor float feed.
What is your understanding of what that refers to?
MR. PROST: Object to form. I'm not sure where you're looking.
Q. (By Ms. O'Dell) I thought I just turned the page.
MR. PROST: Oh, we're in the middle of the page where it says "West Windsor float feed," okay. Object to form.
Q. (By Ms. O'Dell) Well, to be clear, I was on this page -- I'm going in order -- I was on this page with your chart here. And I turned the page, and this is what I have.
MS. O'DELL: So do y'all have something different?
MR. PROST: Looks like maybe we do. Can you

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show me what you have there?
MS. O'DELL: Yeah. Do you have this page in your exhibit?
MR. PROST: I'm looking for it. That's not our next page. I'm checking to see where it is.
THE WITNESS: I didn't see it. It's not in my stack.
Q. (By Ms. O'Dell) Well, I promise you, I did not write this. I didn't make it up. So this was given to me.
I'm assuming they're your -- that's your handwriting, right?
MR. PROST: Can we go off the record for a second? If I could take a look at it.
(A discussion held off the stenographic record.)
VIDEOGRAPHER: Off the record at 10:42.
(Recess taken.)
VIDEOGRAPHER: We are back on the record at 10:53.
Q. (By Ms. O'Dell) Mr. Downey, before we went on the break, we were talking about Exhibit 5, this is my marked copy that's in front of you, your notes that you took in preparation for your deposition. Specifically we were focused on -- I

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think it's the third page of your notes in relation to your conversation with David Crouse.
A. Yes.
Q. And the note at the top indicates you were discussing with Mr. Crouse ore for J&J or Johnson & Johnson?
A. Yes.
Q. And the West Windsor float is listed under that heading.
What'd you discuss with Mr. Crouse regarding the West Windsor float?
A. West Windsor was the flotation plant in Vermont where grade 66, the talc product we manufactured for Johnson & Johnson, was made. So we discussed the ore for the West Windsor flotation feed.
Q. Which, during Mr. Krauss' time frame, came from Argonaut?
A. That's correct.
Q. And specifically, you focused first on Argonaut main.
And what did you discuss in relation to Argonaut main? Which I'm assuming is short for main ore body, correct?
A. No, that references the Argonaut main

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pit. In Crouse's prior depositions, I had read where he referenced the Argonaut main and the Argonaut east, and I was trying to first question which area we were talking about, so that's what the notation for "Argonaut main" was. And it had been mined out before Mr. Crouse was working there.
Q. But Johnson & Johnson's Baby Powder was sourced by Argonaut main prior to Mr. Crouse's tenure with the company, true?
A. I don't know.
Q. In terms of Argonaut east, what was your discussion? And let me start by saying, what does "Argonaut east" refer to?
A. What Mr. Crouse described was the east Argonaut ore body or actually mine area.
Q. That's part of the same ore body as Argonaut main.
It's one ore body, correct?
A. They are of the same geology. It's just proximity and how the mine is developed, whether it was in one pit versus the other.
Q. Have you ever been to the Argonaut Mine?
A. Yes.
Q. When?
A. First time was, I think, in 2000 or

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2001.
Q. What was the reason for your visit?
A. I was working at the Yellowstone Mine at the time. And I had done a technical processing project. And we had a technical meeting in Vermont. And while I was there, I got a tour of the operations.
Q. Was the technical meeting in Vermont related to the operation of the West Windsor processing plant?
A. No.
Q. What was it --
A. Not that I remember.
Q. What did it involve?
A. It was a technical meeting where process engineers got together and we presented our projects to our colleagues.
Q. So Vermont happened to be the location, but the meeting was not focused solely on the operations in Vermont? You were presenting on your projects in Montana?
A. Yes. I presented a project regarding Montana.
Q. In other words, it was a general meeting of project engineers?

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A. Yes. Yes.
Q. Other than that one occasion, have you been to the Argonaut Mine?
A. Yes.
Q. How many times have you been to Argonaut?
A. Maybe four, maybe six over the -- you know, since 2000, so over the last 15 years, so . . .
Q. And let me ask you, in terms of your visits to the Argonaut Mine, were they for purposes of other general meetings?
A. Other general meetings, yes, mostly. And we've -- my team has worked on a large project in the plant there for the last few years, and so I've been to Vermont quite a number of times.
Q. And what plant are you referring to?
A. Hmm?
Q. What plant are you referring to?
A. Ludlow Mill.
Q. Have you had any involvement in relation to projects or work for the West Windsor Mill?
A. No.
Q. And just so it's clear for the record, the Ludlow Mill was not used to process talc for

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Johnson & Johnson's Baby Powder products, true?
A. Only the crushing was done at Ludlow.
Q. But the processing and other manufacturing processes, such as the float feed, took place at West Windsor, true?
A. That's correct. Yes.
Q. You mentioned that you had visited the Argonaut Mine itself four to six times?
A. Thereabouts. Yes.
Q. Have you had any responsibility for the operation of the Argonaut Mine?
A. No.
Q. Have you been tasked to work on any projects specifically related to the mining operation of the Argonaut Mine?
A. I don't think so.
Q. So looking back to your notes -- let me move the page up here -- you say, "Localized narrow zones of cinders where (sic) selectively removed" -- "were," excuse me -- "were selectively removed."
What's your understanding of the term "cinder"?
A. Cinders is a dark zone of mostly chloride with quartz.

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Q. Is it your understanding that cinders do not involve fibrous material?
A. My notes here from our -- my discussion with Mr. Crouse, he said that there are no asbestos minerals associated with the cinders. It was only chloride and quartz.
Q. So that's what Mr. Crouse told you?
A. Yes, ma'am.
Q. Did you -- well, what, if anything else, did you do to assure yourself that Mr. Crouse gave you accurate information?
MR. PROST: Object to form.
A. I'm not sure what you mean. We had discussions with Mr. Crouse. I was able to ask him questions and follow-up questions, so I think my notes indicate that we talked about a wide variety of questions.
Q. (By Ms. O'Dell) Did you do any independent research regarding cinders as they're present in the Argonaut deposit?
A. I reviewed other geologic papers related to the general geology of Vermont as well as some geologic descriptions of Argonaut itself.
Q. And what papers are you referring to?
A. There were some geology reports that

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Dave Marek gave me.
Q. Were those Imerys internal documents?
A. Some of them were geologic papers by government institutions. I think one or two were either Imerys or Rio Tinto Minerals documents, depending on time frame.
Q. What -- were any of the papers that you're referring to peer-reviewed geology publications?
A. Which ones? I'm not sure what you're asking.
Q. Well, you said you reviewed geologic papers in addition to your discussion with Mr. Crouse, and I'm trying to understand what papers you're referring to.
A. I don't recall which publications these were in, so I can't answer to whether they were peer-reviewed or not.
Q. Do you recall the authors of the publications?
A. No, I don't.
Q. Do you have copies of those --
A. Yes.
MS. O'DELL: Mark, since those were provided by an Imerys employee, we would ask that those be

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made available to us.
MR. PROST: We can discuss that also on the break.
Q. (By Ms. O'Dell) Looking at the next page of your notes, Mr. Downey, it appears that these notes also were made during your call with Mr. Crouse.
A. I just need to get there. Okay. Yes, they were.
Q. And pronounce the first -- spell and pronounce the first word you've written there.
A. Lamprophyre, l-a-m-p-r-o-p-h-y-r-e.
Q. I'm going to make your "r" a little bit -- you're like me. Sometimes your R's sort of don't -- so I just -- I made a little curl.
So dikes?
A. Yes.
Q. Are those often composed of a chloride?
A. They are mafic dikes. They are -- my notes indicate pyroxene, biotite, hornblende, magnetite, olivine and feldspar.
Q. Do you know if they're often composed of chlorite, in fact, in Argonaut deposit or composed of chlorite?
MR. PROST: Object to form.

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A. I don't recall.
Q. (By Ms. O'Dell) Toward the lower half of the page, you have the letters and numbers A0170.9; is that correct?
A. No. That's just a 9.
Q. Just a 9. And 2002?
A. Mm-hmm.
Q. Does that refer to a sample that was taken from Argonaut in 2002?
A. That's in reference to a technical report. That's a report identifier.
Q. And what type of report is it?
A. It's an analytical report.
Q. Is it a testing report?
A. It is a test report that Julie Pier had tested. And the report was sent to Mr. Crouse, so I wanted to talk to him about that.
Q. Were you aware of the report before you talked with Mr. Crouse?
A. Yes.
Q. And had you seen report prior to discussing it with Mr. Crouse?
A. Yes, I had.
Q. And the report contained a positive finding for tremolite, true?

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A. The report indicated that tremolite -- that -- the way -- I think the report said fibrous tremolite was identified in a waste-rock sample.
Q. So the answer to my question is "yes"?
A. What was your question again?
Q. My question was, the report indicated fibrous tremolite was found from a sample that was taken from the Argonaut Mine, true?
A. From the fringe area of the Argonaut Mine.
Q. How do you know it was the fringe area?
A. Because I wanted to know where in relationship that occurrence was relative to the ore body.
Q. Do you know what drill hole it was -- the sample was associated with?
A. I believe it was drill hole 98-02.
Q. Let me just -- 98?
A. Yes.
Q. Dash?
A. 02.
Q. 02.
And that would mean a drill hole that was drilled in 1998?
A. Yes.

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Q. And it was the second hole that was drilled?
A. I believe so.
Q. So I'm just turning one page over in your notes. And it says, "Privileged and Confidential: Call with Jyrki"?
A. Jyrki.
Q. "Jyrki and Pat."
A. Yes.
Q. Who is Jyrki?
A. Jyrki Bergstrom.
Q. And what is -- is it B-e-r-s-t-r-o-m [sic]?
A. Yeah. It's listed there under "Guests."
Q. All right. I see that.
And who is -- is it a Miss Pier or Mr.?
A. Mr.
Q. Mr. Bergstrom. Who is Mr. Bergstrom?
A. He's a geologist.
Q. And who does Mr. Bergstrom work for?
A. He works for Imerys Talc Europe, a French company.
Q. And I want to ask you about Mr. Bergstrom, but first, before I do, who is Pat you're referring to?

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A. That's me.
Q. Oh, so it's a call with Jyrki?
A. Jyrki.
Q. Jyrki.
A. I think it'd be unfortunate if your name was "jerky."
Q. Yes, it would. It would. "Jyrki" sounds much better.
A. Yes.
Q. So did you know Mr. Bergstrom prior to this phone call?
A. I may have met him a few years ago. I knew of him.
Q. And Mr. Bergstrom worked -- works for Imerys Europe?
A. Imerys Talc Europe.
Q. "Talc Europe."
And he is a geologist?
A. Yes.
Q. And what was -- first, who arranged the telephone call with Mr. Bergstrom?
A. Mr. Cary.
Q. How long did the call last?
A. One hour.
Q. Who else was -- if anyone -- was a

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participant in the phone call?
A. Carolyn Geyser at Alston & Bird, Eric Gardner, an Imerys attorney, Jyrki, Mr. Prost, myself, Sarah O'Donahue, Andrew Cary and Jim Robinson.
Q. So this is an accurate list of all the participants on the right-hand side of the page here?
A. Yes.
Q. Very good.
What was the purpose of your call with Mr. Bergstrom?
A. To gain information about talc sourcing from China about Guangxi number 2 grade.
Q. So China, Guangxi number 2?
A. Yes, ma'am.
Q. Just 2 or 2A as well?
A. 2. I don't know if there's a distinction between 2 and 2A.
Q. I've seen in some of the documents it suggested that, but maybe you can explain that to me.
Let me just pause right there. You mentioned that you talked with Mr. Crouse, also, about China; did I hear you correctly?

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A. Yes. Yes.
Q. What was your -- before we get to Mr. Bergstrom, let's just complete that. I apologize.
What else -- what did you discuss with Mr. Crouse about China?
A. About what he knew of sourcing from China. He had visited the mines, so he told me about his visit and what he knew of the geology.
Q. And so Mr. Crouse had visited China, the Chinese mines, at least once?
A. Yes.
Q. And do you know what time period that visit took place?
A. In the 2000s. I don't know if it was --
Q. Would it have been early 2000, since he left the company in early -- you said he left the company in early 2000s?
A. I don't think I said that.
Q. I may have misunderstood. I thought you said he worked in Vermont from late '90s to early 2000s.
A. He had responsibilities and oversight. And he did a lot of work in Vermont, but in addition, other sites, so I don't -- I don't want

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to leave the impression that he only worked in Vermont for a period of time.
Q. You've never visited the mine in China, true?
A. No.
Q. Had no involvement in the working relationship between the Chinese mining company and Imerys, true?
A. That's true. I have no relationship.
Q. And your effort to educate yourself on China involved talking with Mr. Crouse?
A. Yes.
Q. And then talking with Mr. Bergstrom, true?
A. And talking to Julie Pier.
Q. Okay. Those three Imerys employees?
A. Yes, ma'am.
Q. And other your discussions with those three employees and possibly some documents, that's the limit of your knowledge about the sourcing of talcum powder for Johnson & Johnson's talcum-powder products by Imerys?
A. Well, we source the ore, not talcum powder, but yes.
Q. And my question -- it's a good

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distinction, but my question was very specific. It was the sourcing of talc for purposes of Johnson's talcum-powder products.
A. Yes.
Q. Let me ask my question again.
Other than your discussions with those three employees and the review of documents, that is the limit of your knowledge regarding Imerys' supply of Chinese talc ore for purposes of Johnson & Johnson's talcum-powder products, true?
A. Generally. I don't -- sitting here today, I can't recall if I gained other information somehow.
Q. So the answer to my question is, yes, that's the limit of your knowledge?
A. I believe so.
Q. Okay. Back to your discussion with Mr. Bergstrom.
That took place last Thursday, just a few days ago?
A. That seems right. Yes.
Q. And you discussed with Mr. Bergstrom specifically Guangxi crude number 2 --
A. Yes.
Q. -- that is mined in China?

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A. Yes.
Q. What mine does that ore come from?
A. I had to write it down. It's a Chinese name.
Q. Okay.
A. (Document reviewed.) It comes from a single mine called Jizhua, J-i-z-h-u-a, or Jizhua. I don't know how to pronounce it.
Q. Can I see what else you've written on your note there?
So just so we'll have it for the record, you can use it during the deposition, but I'm going to mark it. This is your notes from your call with Mr. Bergstrom?
A. Yes.
MS. O'DELL: And I'm marking that as Exhibit Number 6.
(Exhibit 6 was marked for identification.)
Q. (By Ms. O'Dell) Who is the Guilin Guiguang Talc Development Company?
A. I see you have as much trouble pronouncing that as me.
Q. Yeah. I do my best, but I'm not holding myself as an expert in Chinese.
So who is that company?

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A. The Guilin Guiguang Talc Development Company, they are the mine operators who we source Guangxi number 2 from.
Q. And they're the mine operators, but the mine itself is owned by the Chinese government, true?
A. I don't know who owns it, unless there's document that I reviewed, that I don't recall now, that explains the ownership.
Q. What was your discussion with Mr. Bergstrom?
A. I'm sorry?
Q. What was your discussion with Mr. Bergstrom regarding Guangxi number 2?
A. The name of the mines, the owners of the suppliers, the geology of the deposit, its mineralogy, different procedures, how they controlled the ore, its supply chain, how it got from the mine to the port. Tried to be as comprehensive as I could.
Q. And I've turned the page in Exhibit 5. And you'll see it on the screen there.
Are these notes that you took during your call with Mr. Bergstrom?
A. They are.

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Q. Who provided you with the typed headings?
A. I made those.
Q. And are the handwritten notes your own?
A. Yes, they are.
Q. And so your notes from your call with Mr. Bergstrom would include this page that I'm showing at present.
Are these -- the next page, are those also your notes from the conversation with Mr. Bergstrom?
A. Yes.
Q. And then turn one more page.
Are those notes from your conversation with Mr. Bergstrom as well?
A. Yes.
Q. And I'm going to be where -- I'm just going to write it at the top. Okay.
I've highlighted, if you can see it there, Mr. Downey, two words that you've written off to the side.
Could you tell us what that says, please?
A. Dolomite and magnesite.
Q. Turn here to page 3 of your notes from the Bergstrom call, and it says, "YB," and then it

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looks to the side you've written out "Geologist, 16 years experience on talc."
Is that an individual you're referring to, "YB"?
A. Yes.
Q. Who are you referring to?
A. Jyrki. I didn't know how to spell his name. I forgot that there was a J at the -- a silent J.
Q. So this is Mr. Bergstrom?
A. That's Mr. Bergstrom, yes.
Q. And he works for Imerys Talc America. Where is he -- where does he office?
MR. PROST: This is not true.
Q. (By Ms. O'Dell) Excuse me. I'm sorry. Imerys Talc Europe.
A. Yes.
Q. Where does he office?
A. Somewhere in France.
Q. And does he have responsibility that relates to talc ore that Imerys purchases from Chinese mines?
MR. PROST: Object to form.
A. He's involved in sourcing external ores.
Q. (By Ms. O'Dell) That's not my -- really

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not my question.
My question is, does he have any responsibility as an Imerys employee for the process or the relationship that Imerys has with the Chinese mines that they buy talc ore from?
MR. PROST: Object to form.
MS. O'DELL: Excuse me. What's the objection?
MR. PROST: Vagueness in terms of responsibility in terms of the use of the word "Imerys," whether they're referring to Imerys Talc America, Inc., or, you know, any company that he works for. And there are a couple of other words you used at the end of the question that I thought were kind of vague, and so I'm not sure that he has a foundation to answer those, the way that's phrased.
MS. O'DELL: All right. Well, I'll be happy to rephrase it.
MR. PROST: Sure.
Q. (By Ms. O'Dell) Mr. Bergstrom is an employee of Imerys Europe?
A. Imerys Talc Europe.
Q. Imerys Talc Europe. Let me just -- you spoke to him for purposes of educating yourself

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about talc ore that Imerys purchases -- Imerys Talc America purchases from the Guangxi -- sorry. I should say this. I should be careful -- the Jizhua mine in China, true?
A. The Jizhua? Jizhua? Yes, that mine.
Q. So you spoke with him about that mine, true? When I say "him," I'm referring to Mr. Bergstrom.
A. Yes.
Q. And you spoke to Mr. Bergstrom for purposes of educating yourself about Guangxi number 2, which is an ore grade, true?
A. Yes.
Q. And my question to you is, in Mr. Bergstrom's role as an employee of Imerys Talc Europe, does he have responsibility for interacting with purchasing, overseeing the Guilin Talc Development Company and their mining operation?
MR. PROST: Object to form.
A. He makes periodic visits to there to assess and monitor their production of Guangxi number 2.
Q. (By Ms. O'Dell) What is Mr. Bergstrom's title with Imerys Talc Europe?
A. I think it's senior geology manager.

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Q. Did -- excuse me. Start again.
You stated that it was Mr. Bergstrom's responsibility to periodically visit the mine in China.
Do you have an understanding of how many times that Mr. Bergstrom has been to the China mine?
A. Generally, twice a year.
Q. And for what length of time has he been visiting the mine twice a year?
A. You mean, how long is he on-site during a visit?
Q. No. I mean for what period of time has he been visiting the mine on a biannual basis?
A. I think since 2016.
Q. So it says in your notes, "has visited the Guangxi" -- maybe you mean the -- you mean the Jizhua mine. It's not Guangxi mine. It's Jizhua mine?
A. Jizhua mine. Yes.
Q. J-i-z-h-u-a, mine?
A. J-i-x --
Q. I thought it was a Z.
A. Oh, sorry. Yes. J-i-z-h-u-a.
Q. It says he's visited two times per year

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since 2016. And then below, it says a "minimum of 1 time per year at least."
So in some years he only goes once, correct?
A. Say again?
Q. Some years he only goes once?
A. No. He said that he's been there twice per year, but the minimum requirement would be at least once a year, but he's going there more than once a year.
Q. Next page, were these also notes from your discussion with Mr. Bergstrom?
A. Yes, they are.
Q. And you entitled the page "Other Chinese Mines"; did I read that correctly?
A. Yes.
Q. And it says, "Some Chinese mines are contaminated with asbestos"?
A. Yes.
Q. And think the next bullet says, "Luz," which I'm sure means Luzenac?
A. Luzenac America.
Q. And "Imerys has never sourced from them"?
A. Yes.
Q. What mines are you referring to?

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A. I'm aware of reports of Chinese talc mines that are contaminated with asbestos, and I asked Jyrki what he knew about those.
Q. Do you recall the names of those mines?
A. No.
Q. Did you make a note of that anywhere else in these written papers provided?
A. You mean names of mines?
Q. Yes.
A. I didn't get any names of mines.
Q. Is it your understanding that the only mine that has been used to source Johnson & Johnson's Baby Powder products is the Jizhua mine that you referred to previously?
A. Yes.
Q. And turn the page here in your notes. And you titled these "OC MDL Prep"?
A. Yes.
Q. What does that "OC" stand for?
A. Ovarian cancer.
Q. And what were these notes in reference to?
A. These are notes about the notice topics that I had been assigned.
Q. Were these notes made in conjunction

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with a meeting with counsel?
A. Yes, they were.
Q. And when did this meeting take place?
A. In June or early July. I don't recall.
MR. PROST: Just to be clear, these notes were pertaining to a topic that were later determined to go to Julie Pier, just so there's clarity in the record as to why he's taking notes on Topic 1 on composition, just for the record.
Q. (By Ms. O'Dell) And this was information that you learned, Mr. Downey, during that meeting, you made notes of that, correct?
A. Well, I made notes about the certain topics. Other notes in here I had learned before this meeting.
Q. I ask you to turn to the next page of Exhibit 5, and it says "Topic 2"?
A. Mm-hmm.
Q. And it talks about the "mines that supplied."
And I'm assuming you mean supplied talc for Johnson & Johnson products?
A. Yeah.
Q. And you list four mines under the mine: Hammondsville, Argonaut, Rainbow and Hamm.

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It says in parentheses, in relation to Hammondsville, "counsel to look for historical information"?
A. Yes.
Q. Were you provided historical information about the Hammondsville Mine?
A. I don't believe so.
Q. It says, "Argonaut (info from Marek)"?
A. Marek. Dave Marek.
Q. And that's -- and you talked to us about a meeting you had with Mr. Marek.
Did he provide you any written documentation regarding Argonaut?
A. Yes. That's what we discussed.
Q. You're talking about the geological paper?
A. The geology papers and such, yes.
Q. In relation to Rainbow, did counsel provide you historical information regarding that mine?
A. No. As I recall, I don't think we have information on that. I don't know, though.
Q. And then as it relates to the Hamm Mine, H-a-m-m, did counsel provide you historical information regarding that mine?

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A. I don't believe so. Wait a minute. I think I saw some -- I briefly reviewed some documents that did have some information on Hammondsville, Rainbow and Hamm in a document I produced yesterday.
Q. Was that an internal document from Imerys?
A. I believe that's in the production. It's the documents that have been produced.
Q. Any other information that you have reviewed regarding the Hammondsville, Rainbow or Hamm mines?
A. I'm not sure what you mean "any other documents."
Q. You mentioned you reviewed one document regarding those mines. Is that it?
A. It was a stack of papers. I don't know if they were all in one document or not.
Q. Okay. Regarding the Val Chisone --
A. Sorry. Sometimes I get focused on certain things. I have seen information on the due diligence for some of these mines.
Q. And any other information?
A. Not that I recall.
Q. The Val Chisone Mine you reference in

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the middle of the page here -- sorry, I should move it up -- that's an Italian mine? Talc mine?
A. Yes.
Q. And it's owned by Imerys Talc Italy, true?
A. That's my understanding, yes.
Q. When did Imerys Talc Italy purchase the Val Chisone mine?
MR. PROST: I'll object to form, and outside the scope.
Q. (By Ms. O'Dell) You may answer.
A. I don't know.
Q. Do you know the general time period?
A. No.
Q. If you'll turn, Mr. Downey, to -- a few pages over in your notes, there's a page that begins "Sample retention"; do you see that?
A. Yes.
Q. And so sample retention talks about core. Does that refer to drill cores?
A. Yes, ma'am.
Q. And according to your note, the drill cores "are kept in a couple shipping containers stacked in boxes" and it's located at the Argonaut Mine shop; did I read that correctly?

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A. Yes.
Q. Who provided that information to you?
A. Dave Marek.
Q. And that's true today, that those core -- drill cores are stored in a shipping container at the Argonaut Mine?
A. I believe so.
Q. You then refer to "infill." What are you referring to there?
A. The development drilling. We call it development drilling, or infill drilling.
Q. And the development drilling, just for purposes of the jury, distinguish that from the process of drilling cores for mine exploration.
A. It's -- part of the development aspect of mining is once -- the exploration generally defines the limits of the ore body, but you need additional information to more appropriately plan the specific areas that you're going to be mining and the quality as well so that you can estimate, for budgeting purposes and things like that, how much talc is going to be mined, how much overburden needs to be removed. So you need to gather that type of information in advance. And so we do that with infill drilling.

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Q. And it says, in relation to that, "retains might be held for short periods of time, but plastic bags deteriorate and numbers"?
A. Numbers. Sample numbers.
Q. "Sample numbers rub off."
And then it says, "Stored at." What is that, Stone House Garage?
A. Yes.
Q. And what's the next word?
A. It says, "or Green building."
Q. "Green building."
And those are both located at the Vermont -- let me ask you. Where are those located?
A. Near the Ludlow Mine.
Q. Would those be near the Argonaut Mine?
A. Or sorry. Argonaut Mine, yes.
Q. And there are retains that are currently being stored at Stone House Garage or the green building, true?
A. I'm not sure, because the notes indicate that they're only retained for short periods of time, and then exposure to sun and the weather, you know, the bags deteriorate, so --
Q. And did Mr. Marek provide that information to you as well?

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A. That's what he told me. That's -- yeah.
Q. Did you -- excuse me. Sorry. Were you finished?
A. He provided that -- these are my notes that I took of information that he provided.
Q. Did you ask Mr. Marek if there are infill retains currently being stored at one of these locations near the Argonaut Mine?
A. I don't recall if I asked that or not. And even if I did ask, I don't recall that he may have said.
Q. What's the next word you put there, the next heading?
A. "Blast holes."
Q. And when you say, "no retains," are you saying that those are not maintained beyond seven days?
A. The seven-day is a turnaround for the analyses, yes, prior to. Because it's associated with near-term mining activity, we need to have a quick turnaround from our lab.
Q. Do you know what happens to those samples after they've been, you know, tested?
A. They're discarded. I don't know how long afterwards, but there's numerous blast holes,

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and they're discarded.
Q. Just to make sure I understand, you say "records" and "TEM data stored in Julie Pier database"; did I read that correctly?
A. Yes.
Q. And that's -- and who -- and Mr. Marek provided that information to you as well, or somebody else?
A. I believe that was from Mr. Marek, yes.
Q. And it says, "C of A's," which I'm assuming means certificate of analyses, "stored at Ludlow server," or "on," "at," "on." I'm not sure.
A. I think it was "at Ludlow server," yes.
Q. Who provided that information to you?
A. Mr. Marek.
Q. And then I skipped this, I'm sorry.
"Electronic drill logs, assay spreadsheets, etc., stored on the local server at site."
Did Mr. Marek provide that information to you?
A. Yes, he did.
Q. And what server would Argonaut-related drill logs, assay sheets, et cetera, be stored on?
A. I think he was referencing the Ludlow file server.

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Q. So there's not an Argonaut server and a Ludlow. It's all one server?
A. All one.
Q. Okay. Just a few more items here.
You have on the next page of your notes, "Topic." And I'd like to just ask generally when you made, you know, these notes.
A. I think early July.
Q. Was it a part of the same in-person meeting you had with counsel?
A. One of them.
Q. One of them.
And do you know if it was the first or the second meeting?
A. I don't remember.
Q. And in terms of documents that might be of assistance, who provided the information that you list under that category, or that heading?
A. I think it was a combination of me and counsel suggesting different types of documents that might be helpful.
Q. Let me ask you this: Does that say "SharePoint"?
A. Where? I don't know where you're --
Q. At the bottom. I'm sorry. Excuse me.

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I'm --
A. Yes.
Q. That says "SharePoint"?
A. Yes.
Q. And that's Houston quality, I'm assuming, "procedures"?
A. Yes. "Houston Q procedures" would indicate quality procedures.
Q. And then good manufacturing practices, "GMPs"?
A. Yes.
Q. And those are documents that you described to us earlier that you found on your own?
A. I didn't search all of the ones for Houston. I grabbed samples, or, you know, typical types.
Q. If you'll just clarify for me, Mr. Downey, there are three more pages of notes. And just let me ask a general question. They all have at -- most of them have "Topics" at the top. Are these all notes that you took with -- excuse me.
Were these notes sort of a continuation of your notes taken during the meetings with counsel?
A. Yes, ma'am.

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Q. Let me ask you to look at this note. It's on the next-to-the-last page of the exhibit. And it says, "Argo blending with Hammondsville." Does that indicate that Argonaut talc ore was blended with Hammondsville talc ore?
A. That references part of the J&J supply agreement circa 1989 at the time frame that Windsor Minerals was purchased by Cyprus, that there was a GMP that indicated that Argonaut ore blended with Hammondsville was part of their procedure. And it was specifically referencing the topic of blending that was included in the notice.
Q. And I've turned to the last page of your notes, Exhibit 5. And it has, at the top, "Blending Vermont"?
A. Yes.
Q. "Hammondsville, Argonaut, Hamm, Rainbow"?
A. Yes.
Q. Who provided the information on this -- that's noted here?
A. I did.
Q. Who gave the information to you?
A. Some of it I had seen in documents related to other cases.

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Q. You refer to "JM." Who does that refer to?
A. John McMeekin.
Q. Who is John McMeekin?
A. He's an attorney for Imerys. Well, he's not an Imerys attorney, but he --
THE WITNESS: He's an attorney for them?
MR. PROST: Outside counsel.
A. Outside counsel.
Q. (By Ms. O'Dell) What is the Pipes case?
A. It's a case in Oklahoma that I gave a deposition on a few weeks ago.
Q. What was the injury that was involved in that particular case?
A. Mesothelioma.
MS. O'DELL: Give me just a minute.
(Pause.)
MS. O'DELL: My colleague has pointed out to me some notes from a conversation with Robin Reilly, and those were not made a part of my exhibit that I was previously given.
Q. (By Ms. O'Dell) So do you have those as . . .
A. Yes.
MS. O'DELL: Can I have an extra copy of

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that at the break, please?
MR. PROST: Sure.
MS. O'DELL: I'll try to -- for purposes of time, we'll move forward, but I need a copy for mine.
Q. (By Ms. O'Dell) So this is a conversation of notes, it appears, from a conversation with Robin Reilly that you referenced earlier?
A. Yes, ma'am.
Q. And that occurred on August the 3rd?
A. Yes.
Q. And that was Friday or Saturday?
A. Last Friday.
Q. You note here, Mr. Downey, that you talked about -- you mentioned this a little bit earlier, and I won't belabor it, but I want to make sure I cover this.
With Miss Pier Reilly, you spoke with her about her work at the lab at Ludlow?
A. Yes.
Q. And the samples being analyzed and the frequency with which they were analyzed, true?
A. Yes.
Q. And according to this, y'all had

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discussions, as well, about the process float for J&J talc, which I'm assuming refers to the West Windsor process?
A. Most -- well, it actually starts, actually, at the mine and through crushing. So it's -- it does include West Windsor, but it's -- I wanted -- I asked her specifically what she knew about all of the supply, not just one focused area.
Q. Fair enough.
Any other discussions that you had with Miss Pier Reilly about -- excuse me, or in preparation for your deposition?
A. Not that I recall, no.
Q. Other than the Imerys employees we've discussed so far -- Mr. Crouse, former employee; Mr. Marek, Miss Pier and Miss Pier Reilly -- were there any other Imerys employees that you spoke with about your testimony here today?
A. Yes.
Q. Who?
A. Hans Bruning.
Q. What's -- how do you spell Mr. Bruning's last name?
A. B-r-u-n-i-n-g.
Q. And who's Mr. Bruning?

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A. He's a geologist at Vermont currently.
Q. And what was the purpose of your discussion with Mr. Bruning?
A. I wanted to discuss the geology of the deposit and the mine planning and ore-control aspects of --
Q. Excuse me.
A. -- mine planning and ore-control aspects.
Q. Of which mines?
A. Of Argonaut.
Q. Did you speak with Mr. Browning [sic] about --
A. Bruning.
Q. Bruning. Sorry. I can't read my -- Bruning.
-- about any other mines besides Argonaut?
A. I don't believe I did, no.
Q. Did you speak with Mr. Bruning about any other topics related to your deposition here today other than --
A. What do you mean?
Q. -- geology and mine planning of Argonaut?
A. Talked about his kids.

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Q. Do you and Mr. Bruning office in the same building?
A. No. My office is in Montana.
Q. I thought you said he was in Montana.
A. No, no, no. In Vermont.
Q. In Vermont, okay.
So Mr. Bruning is in Vermont?
A. Yes.
Q. Had you known Mr. Bruning prior to your call?
A. Yes.
Q. And did you initiate that call?
A. Yes, I did.
Q. Was there anyone else that participated on the call either in person or on the phone?
A. No. And it wasn't a call. It was a visit in person.
Q. Where did that meeting take place?
A. In Vermont.
Q. When did it take place?
A. Early June.
Q. And was the purpose of your meeting with Mr. Browning to --
A. Bruning.
Q. Excuse me. Bruning.

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-- to prepare for your deposition today?
A. Yes.
Q. How long was that meeting?
A. About an hour.
Q. Where did you meet in Vermont?
A. At the Ludlow Mill and Argonaut Mine.
Q. You mentioned that Mr. Bruning is a geologist.
What's his position with Imerys?
A. I don't know the name of his title, but he does geology and mine planning for our mines.
Q. In Vermont?
A. In Vermont and elsewhere.
Q. And elsewhere.
What's Mr. Bruning's first name?
A. Hans.
Q. Hans.
Is he an employee of Imerys Talc America?
A. I believe so.
Q. Is he also an employee of Imerys -- any other entity of Imerys?
A. No, I don't think so.
Q. Does Mr. Bruning have oversight or supervisory responsibility over the mining operations at Argonaut presently?

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A. Presently, yes, but he was not employed during the time frame that we were supplying product to Johnson & Johnson from Vermont.
Q. Did you travel to Vermont specifically to meet with Mr. Bruning?
A. No. I was there on other business.
Q. Did it relate to issues regarding talcum powder -- excuse me.
Did your visit relate to any aspect of litigation?
A. Say again? The primary purpose of the specific visit?
Q. Yeah.
A. No.
Q. Let me just ask you again. I'm sorry.
What was the purpose of your -- primary purpose of your visit to Vermont?
A. A project review of a processing project at the Ludlow Mill.
Q. And that's a project you mentioned to us earlier?
A. Yes.
Q. You mentioned earlier, Mr. Downey, that you met with counsel twice before your call with Julie Pier on July 27th, if my memory's correct,

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and --
A. I believe I met with counsel about four times. And I think we met twice before then. I didn't record -- I don't remember the dates of the meetings.
Q. You believe you had approximately four meetings with counsel in preparation for your deposition here today?
A. I think so, yeah.
Q. And it's your memory, your best recollection, two of those occurred before your call with Julie Pier, and I'm assuming two occurred after the call, thereabouts?
A. I think -- I think so, yeah.
Q. Do you have a sense of how long each of those meetings were after your call with Julie Pier?
A. Generally, the times that I met in person with counsel, we met for about a day and a half.
Q. So just to summarize, you had approximately four meetings with counsel, and each of those meetings lasted about a day and a half, fair?
A. Fair.

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Q. In terms of going forward in the deposition, Mr. Downey, a couple things I want to see if we can just agree on, okay? We agreed on a few things so far. Let's see if there are a few other things we can agree on.
First thing is that asbestos is a carcinogen. Can you and I agree on that?
A. Yeah. I agree that I think it's well-known that asbestos can cause some types of cancer.
Q. So is that fair? Asbestos is a carcinogen?
A. It can cause some types of cancer, yes.
Q. Which is a fair definition of a carcinogen?
A. Sure.
Q. It causes cancer, or can cause cancer in humans?
A. Yes.
Q. Can we agree that Imerys Talc America -- and I'm going to put in parentheses "RTM," Rio Tinto -- and Luzenac had a no-asbestos policy for talc supplied to J&J; can we agree on that?
A. Yes.
Q. Can we agree that Imerys -- oops. I

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misspelled talc. Sorry. I left a "c" off.
A. I was wondering who was going to catch that.
Q. Yeah, yeah. I'd look back periodically. I'm just trying to write so neatly. It's hard. I'm feeling some pressure. Imerys --
A. Your handwriting is better than mine. I appreciate that.
Q. So Imerys -- and I'm just going to say "Imerys" in short for Imerys Talc America in the parenthetical, is that okay with you? Because it takes a long time.
A. Okay. "Luzenac America" is on your first statement there.
Q. So I should put "America" right here?
A. Yes.
Q. And "Imerys Talc America." I'm just going to go ahead, since I've done that much, "RTM & Luzenac America was/is responsible for ensuring that the talc sold to J&J was" -- since they're currently selling it -- "is asbestos free"; can we agree on that?
MR. PROST: Object to form.
A. We test our product to ensure that it doesn't contain measurable asbestos, and that's

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what I can agree to.
Q. (By Ms. O'Dell) So we can't agree that it's "free," so I'm going to cross that out. But --
A. I can't -- you're going to need to move it because I can't see that area.
Q. Thank you. So do you see that now?
So you cannot agree that Imerys Talc America is responsible for ensuring that talc sold to J&J was/is asbestos free, but you'll agree that it was -- asbestos was "below detectible limits"?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) Is that -- can we agree on that?
A. Generally speaking, I would agree.
Q. Okay. "Imerys Talc America does ensure that talc is asbestos free" --
MR. PROST: Object to form; misstates testimony.
Q. (By Ms. O'Dell) -- is that fair? Because you wouldn't agree it's not -- you won't agree it's asbestos free.
You agree that it's below detectible limits, true?
MR. PROST: Same objection.

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A. Our talc -- we have a rigorous testing program that also includes not only the testing itself, but our knowledge of the ore deposits and the testing that -- and sampling and mapping that we do continually through the process, we are confident that our products are safe, but in terms of a detection limit, I'm not the expert on that. Julie Pier can speak to that.

But the scientific instruments are not available to tell us that our product is, quote-unquote, asbestos free. We can't say that in this room, that the air in this room is asbestos free and we've been, you know, in this room together for a few hours and, you know, even say that the air in this room asbestos free. So I can't really agree with the way that you've written that.

Q. Okay. Let me say this: "Imerys does not certify that talc sold to J&J is asbestos free" --

MR. PROST: Object to form.

Q. (By Ms. O'Dell) -- is that fair, based on your testimony?

A. We have a rigorous testing program where we test our product. We exceed all government

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regulatory requirements for the safety of our product. And we believe in that strongly. But in terms of the characterization of, quote-unquote, asbestos free, as I said before, we cannot make that statement. Nobody can make that statement, the same as nobody can guarantee that the air that we are breathing in this room is, quote-unquote, asbestos free.

Q. So Imerys -- it's a true statement to say Imerys does not certify that talc sold to J&J is asbestos free, true?

MR. PROST: Object to form.

A. I don't think you can answer that as a true-or-false question. You need to understand the testing methodologies, the regulatory environment and all that. I can't agree to try to answer that as a true-false question.

MS. O'DELL: Move to strike as nonresponsive.

Q. (By Ms. O'Dell) That's a true -- that's either true, Mr. Downey, or it's not true.

MR. PROST: Object --

Q. (By Ms. O'Dell) Imerys can't -- you've testified, and I can read it back to you, that Imerys cannot certify that talc sold to J&J is

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asbestos free, true?

MR. PROST: Object to form. This is repetitive questioning three or four times now. And he's answered it the best that he can.

MS. O'DELL: He has not answered my question. It's a true-or-false question. It's a fair question.

Q. (By Ms. O'Dell) If you think it's false, tell me how it's false, but I think what I've done is summarized your previous testimony.

Imerys does not certify that talc sold to J&J is asbestos free, true or false?

MR. PROST: Object to form. He's told you he can't say just "true" or "false." He's answered the best that he can. You've asked it five times. He's -- the same way. He says he can't answer just "true" or "false."

MS. O'DELL: To be fair, don't coach the witness. It's a true-or-false question. It's very clear.

Q. (By Ms. O'Dell) And I'm asking, is that a true or false statement, Mr. Downey?

MR. PROST: Object to form. My understanding of the deposition guidelines are to avoid repetitive questions. You've now asked the

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same exact question five times, which he has told you he can't answer just "true" or "false." He's answered the best way that he can. I'm not coaching him. I'm just stating what's on the record here and what's happened.

MS. O'DELL: It's a fair question. What the deposition protocol says is, one, you can't coach the witness. Number two, there can't be objections that are lengthy. To be fair, I think that's maybe where you are.

But he just said in the last few minutes, nobody can certify that talc is asbestos free.

Q. (By Ms. O'Dell) You've said that, right?

MR. PROST: Object to form.

Q. (By Ms. O'Dell) You said -- you said you can't certify that talc is asbestos free because you don't know if this room doesn't have asbestos in it, fair?

MR. PROST: Object to form.

A. Again, our products meet the highest safety standards. They exceed the regulatory requirements --

Q. (By Ms. O'Dell) Let me stop you right there. Let me stop you right there.

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I'm not asking you about your testing protocol. Miss Pier's going to talk about that. I'm asking you about -- I'm not asking you about the regulatory framework.

I'm asking you, does Imerys certify that talc sold to J&J is asbestos free? That's the question. I asked that a few minutes ago. I understood your answer to be, no, Imerys does not certify that.

MR. PROST: Object to form. That misstates what he said. You're not liking what he's saying, but he's given you the answer to the question. Object to form.

Q. (By Ms. O'Dell) Is that what you said, Mr. Downey?

A. We certify that our talc does not contain measurable asbestos. And your question needs to be understood in the context of both the scientific limits of detectability, to which Julie Pier will speak to, but also the regulatory requirements.

Q. So it's your testimony that Imerys certifies to J&J that in the talc sold to J&J for talcum-powder products, asbestos is below the detectable limit, fair?

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MR. PROST: Object to form.

A. Again, providing the context that I've previously repeated, yes.

Q. (By Ms. O'Dell) And "below detectible limits" does not equal asbestos free.

MR. PROST: Object to form.

Q. (By Ms. O'Dell) True?

MR. PROST: And outside the scope.

A. That depends.

Q. (By Ms. O'Dell) True?

A. No, that depends.

Q. It can be true?

MR. PROST: Same objections; asked and answered.

A. It depends.

Q. It can be true?

MR. PROST: Same objections; asked and answered.

A. It depends.

Q. (By Ms. O'Dell) All right. You say it depends. Okay. I'll put that right there, all right?

A. I can't see it.

Q. Oh, sorry. I'm running out of room here. You say that depends.

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I wrote, "Below detectible limit does not equal asbestos free," you said it depends?

A. Yes.

Q. Okay. Let me try one more time.

"Imerys cannot make the statement that talc sold to J&J is asbestos free."

MR. PROST: Objection; form, outside the scope, asked and answered maybe ten times now.

Q. (By Ms. O'Dell) You agree with that, don't you?

MR. PROST: Same objections.

A. Is there a way to expand it so I can read it?

Q. (By Ms. O'Dell) I'll try.

A. Now I'm getting dizzy.

Q. It's very sensitive. Sorry.

Can you see that? Can you see that, sir?

A. Yes, I can. Sorry.

Q. Agree? Do you agree with that statement?

MR. PROST: Same objections; asked and answered multiple times.

A. In the context of the limitations of the scientific instruments, generally I would agree with that.

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MR. SILVER: Leigh, if it's a good time, it's been almost 90 minutes, let's see if we can take a break, see if lunch is here.

MS. O'DELL: Give me just one minute. I'm just going to mark this exhibit, Exhibit 7, our notes here, and we're on the Elmo.

(Exhibit 7 was marked for identification.)

MS. O'DELL: We can go. We can take a break now.

VIDEOGRAPHER: Going off the record at 12:19.

(Recess taken.)

VIDEOGRAPHER: We are back on the record at 1:10.

Q. (By Ms. O'Dell) Mr. Downey, would you agree with me that baby powder in Shower-to-Shower talc products do not have any therapeutic benefit?

MR. PROST: Object to form.

A. You're asking a health question. I don't know what you mean by "therapeutic," but to the extent that they could prevent rash and infection, if that's therapeutic, I suppose so.

Q. (By Ms. O'Dell) Is it your understanding that talc-powder products can prevent infection?

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A. I'm sorry?
Q. Is it your understanding that talcum-powder products can prevent infection?
A. I don't think that's what I said.
MR. LOCKE: Objection; beyond the scope.
Q. (By Ms. O'Dell) I thought that's what you said, but . . .
You said, "You're asking a health question. I don't know what you mean by that, but to the extent that that could prevent infection, it's therapeutic."
I'm saying, is it your understanding that talcum-powder products prevent infection?
MR. PROST: Object to form.
MR. LOCKE: Same objection.
A. I thought that I said that to the extent it could prevent chaffing and, therefore, an infection. That's what I meant.
Q. (By Ms. O'Dell) That's what you meant, okay.
So in your mind, that would be a therapeutic benefit?
MR. PROST: Same objection.
A. It could be. Again, I'm not a health professional.

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Q. (By Ms. O'Dell) Let me show you what I've marked, Mr. Downey, as Exhibit Number 8.
(Exhibit 8 was marked for identification.)
Q. (By Ms. O'Dell) Have you seen this document before?
A. (Document reviewed.)
MR. SILVER: Leigh, the copies that you handed out have no Bates number. Is there a Bates number on the document?
MS. O'DELL: There is. Sorry.
MR. SILVER: Then could I just -- going forward, if we could just read Bates numbers into the record, it makes it easier when we have just the --
MS. O'DELL: That's fair, because I've got probably a handful that, when they copied, they didn't have -- they didn't copy with a Bates. And my -- I'll try to point that out. I didn't realize those were some of them.
MR. SILVER: That's fine.
Q. (By Ms. O'Dell) But this -- I've marked it as Exhibit 8. It's a document that has the Bates number IMERYS 050651.
Have you seen this document before, Mr. Downey?

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A. It does not look familiar, no.
Q. All right. This was a document prepared by Rio Tinto Minerals for IMA.
Are you familiar with IMA?
A. I am familiar with an IMA.
Q. And which IMA are you familiar with?
A. Industrial Minerals Association.
Q. Right. And so -- and it was prepared by Ed McCarthy, Julie Pier and Erik Ronald; do you see that?
A. Yes.
Q. And we talked about Miss Pier being an employee of Imerys.
Are you aware that Ed McCarthy is an employee of Imerys?
A. He's a former employee. He retired.
Q. Do you know when Mr. McCarthy retired?
A. About a year and a half ago.
Q. And do you know Erik Ronald?
A. I knew him, yes.
Q. And who is Mr. Ronald?
A. He was a geologist with the company.
Q. So these are three current or former Imerys employees that prepared this summary for the international minerals association in October of

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2009?
A. For the who?
Q. International minerals association.
A. No.
Q. Was it --
A. Industrial Minerals Association.
Q. Excuse me. Sorry.
Can I say "IMA" for short?
A. You bet.
Q. Okay. I'll say that again.
Edward McCarthy, Julie Pier and Erik Ronald were Imerys employees who prepared this summary regarding talc for IMA, and it's dated October 2009?
A. Yes.
Q. And you'll notice there is -- should be a Bates number, IMERYS 050651, indicating that this came from documents produced by Imerys in this litigation.
A. The copy I have does not have any Bates references on it.
Q. I'll represent that that's the case, Mr. Downey.
I want to ask you a couple of questions about this document, because it goes over some of

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the general geology of the mines in Vermont and also in China. And I apologize, again, for giving you a copy without the Bates number, and so we're going to have to work our way through this by counting pages.

A. Okay.

Q. And I apologize.

So if you will turn, I think it's 14 pages over --

A. Including the title page?

Q. Yes, including that.

So 14 pages, you'll see at the bottom of the page -- I'm going to reference, Mr. Downey, a heading with "Vermont"; do you see that? Do you see that?

A. Oh, okay. Yeah.

Q. Okay. And so, of course, we've been talking about Vermont a good deal already today because that's where Imerys, in part, sourced talc for J&J.

And Mr. McCarthy and others write here that Vermont has produced talc for over 100 years. I'm not going to read all this, but just to give you a little connection. It goes on to say, "Powder production began in Johnson in 1902. And at one

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time some seven mines were active in the state, but production has now been limited to one mine, the Argonaut"; do you see that?

A. Yes.

Q. And that's consistent with your understanding of mining operations owned by Imerys in Vermont, true?

A. Yes. I just want to make sure I'm aware of the time line on things.

Q. Okay. And in talking about the talc deposits -- or I should say "deposit" -- in Vermont where the Hamm Mine, the Hammondsville Mine, the Rainbow Mine, Argonaut that we've talked a lot about, those mines are located essentially in the same geologic formation that contains talc, true?

A. Generally speaking, that's my understanding.

Q. And according to Mr. McCarthy and Miss Pier, talc in Vermont was formed from the alteration of peridodite -- how would you say that?

A. That looks like a typo.

Q. What would you -- what do you think it should say?

A. They might mean peridotite.

Q. Peridotite or, to make it a little bit

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easier, ultramafic?

A. Ultramafic.

Q. "Ultramafic rocks of Precambrian age first into serpentine and then to talc and magnesium carbonate by reaction with carbon dioxide."

Is that consistent with your understanding of how talc was formed in the location where the Vermont mines are located?

A. No.

Q. Okay. How is your understanding different?

A. That the source rock was dunite, not peridotite.

Q. Would you agree it's ultramafic rock?

A. Yes. That's a very broad description.

Q. Okay. So you agree it's ultramafic rock. You just don't agree it's peridotite -- how do you say that? Perry dot --

A. Peridotite.

Q. Peridotite. Thank you.

You don't agree with that. You say it's made out of what kind of rock?

A. Dunite.

Q. Okay. How do you spell dunite?

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A. D-u-n-i-t-e.

Q. But you agree that it's first serpentine and then it morphs into a talc and magnesium carbonate in certain portions of the geologic formation, true?

A. Generally speaking, I'd say that's correct, but I think the description of the geology deposit by Crouse is much more informed.

Q. And what description are you talking about? Should I make a telephone call with Mr. Crouse?

A. The phone call as well as what he described in the depositions that I reviewed. He gave two depositions.

Q. And you think those are more informed than Mr. McCarthy, Miss Pier and Mr. Ronald?

A. Yes, I do.

Q. And you based that just on reviewing his depositions? You think that's a more correct summation of the geology?

A. Well, in part, Mr. McCarthy's not a geologist; he's a chemical engineer, Ph.D.

Q. Mr. Ronald's a geologist?

A. Yes.

Q. And Miss Pier, you held her out to be an

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expert in matters related to talc, true?
MR. PROST: Object to form.
A. Specifically, I think that she's a mineralogist.
Q. (By Ms. O'Dell) She's a mineralogist?
A. I believe that's her training.
Q. Goes on to say, "The outside of the deposit will usually have a thin blackwall containing a biotite-chlorite schist in contact with the surrounding host" -- problem -- "peridotite"?
A. There you go.
Q. I can't say it. It's close. Better.
"Subsequent shearing has complicated the structures and created zones of highgrade platy talc. Grades typically run 45 to 57 percent talc, with magnesite, chlorite, serpentine, quartz and mica being the major impurities."
That's consistent with your understanding of Vermont deposits, true?
A. Again, the surrounding host wasn't peridotite. And I think that the geologic description by Mr. Crouse is correct.
Q. Mr. Crouse hasn't published that geologic description, true?

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A. I'm not sure.
Q. And you see no Imerys production documents, as you refer to them, where Mr. Crouse has delineated his thoughts on the geologic formations, true?
MR. PROST: Object to form.
A. There might be. I can't recall right now.
Q. (By Ms. O'Dell) But you're not -- you can't tell me if there are, true?
A. I think there are, but right now, I can't -- I've reviewed numerous documents.
Q. And you know, Mr. Downey -- or you may not know -- that you reviewed depositions that are not a part of this case and, I'm assuming, subject to a protective or confidentiality order?
MR. PROST: Object to form.
A. I don't know.
Q. (By Ms. O'Dell) Let me ask you to turn probably four or five pages over? Yeah, five pages over. Do you see a section on China?
A. Before or after? Which way are we turning?
Q. A little farther into the document, so five pages further into the document, you'll see a

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subsection that's entitle "China"; do you see that?
A. Yes.
Q. And this describes, generally -- and we're going to go into this in some more detail, but trying to get some kind of background here for the jury.
Is it says, "China has some 120 working talc mines located in three provinces, Liaoning and Shangdong in the North and Guangxi in the south."
And we talked about Guangxi being the source of Johnson & Johnson talc, true?
A. Guangxi number 2 is the grade that we use for Johnson & Johnson product, yes.
Q. And they're talking about -- that's -- Guangxi is the name of the province; is that your understanding?
A. I forget how the name is derived.
Q. All right. It says, "Almost all the talc," referring to China, "is of the metasedimentary origin and much of it, especially in Liaoning and Guangxi, is high purity and high brightness."
Is that consistent with your understanding of the talc deposits in China?
A. I believe metasedimentary is correct,

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and certainly Guangxi is high purity and high bright. I can't speak for Liaoning.
Q. And turn it over to the next page, the document, and you'll look about midway down, the paragraph beginning "The talc veins"; do you see that?
A. Yes.
Q. And it's talking about Chinese ore deposits, it's chlorite, dolomite, magnesite and quartz are the main contaminants contained in those deposits.
Is that consistent with your understanding?
A. Well, this is a section of a document -- I can see what it says, and I'm not sure what they're referencing to. I can't tell what deposits they're talking about, but that's what it says here.
I might also add that this appears to be a document that's in some form of draft and review, so I don't know that it's the finished product.
Q. What's your understanding of the impurities or contaminants contained in the Chinese ore deposits where Imerys buys talc for J&J?
MR. PROST: Object to form.
A. Generally speaking, it's for the Guangxi

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number 2. It's my understanding that the other minerals present include chlorite, dolomite, I'm not sure about magnesite, and a trace of quartz, I believe. I can't tell from this document whether it's the ore prior to selective mining or things like that. It might be the -- the in placement. I can't tell, either.

Q. Is dunite a type of peridotite?

A. Let me think. I'd have to refer to my notes from Crouse and see if I can refresh my memory. (Document reviewed.)

Q. If you don't know, Mr. Downey, just tell me you don't know, but if you -- I'll give you a minute to look at your notes.

A. (Document reviewed.) My notes indicate that the talc mines we're talking about in southern Vermont form from pure dunitic serpentinite. They were derived from dunite. Elsewhere --

Q. Sir, I'm asking about China, not Vermont.

A. Right. Oh, I'm sorry. I lost your question.

Q. Okay.

A. Your question was about peridotite, wasn't it?

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Q. It was. Yeah. You're right. Keep going. I'm sorry.

A. Elsewhere in my notes, peridotite is a different serpentinite rock composed of pyroxene. The dunite is composed of olivine. And it's very -- that's a very pure magnesium silicate. So peridotite is different than dunite.

Q. But they're both ultramafic rocks, true?

A. Generally, yes, that's my understanding.

Q. And so in terms of peridotite, dunite is a type of peridotite rock. It's different, but it's a type of peridotite rock, true?

A. I don't -- I think that I would say that it's a different ultramafic. Peridotite is composed of pyroxene, whereas dunite is composed of olivine.

Q. We might agree to disagree on that point, but we'll move on. We can get through the rest of our deposition without coming to an agreement on that point.

Let me show you what I'm marking -- I'm going to transition to a new topic area, and that is the topic on the notice that relates to 2A, Roman numeral I, 2A, the identities and owners of the source mines for Imerys or its predecessors

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that sold or supplied talc for use in Johnson & Johnson products.

And so I'm going to hand you what I've marked as Exhibit Number 9.

(Exhibit 9 was marked for identification.)

Q. (By Ms. O'Dell) And I promise, there are only a few of these, but this is the second one where the Bates didn't print, and rather than kill another ream of paper, we have -- I've just put, with the help of my colleague, put stickies on the pages where we're going to be having a discussion.

Have you -- it's --

MR. SILVER: Can I just interrupt you for one sec? Has anyone else lost the real-time? Because I lost it, and I just don't know how far back . . .

THE REPORTER: Can we go off the record for a minute?

MS. O'DELL: Yes.

VIDEOGRAPHER: Off the record at 1:34.

(Recess taken.)

VIDEOGRAPHER: We are back on the record at 1:41.

Q. (By Ms. O'Dell) Mr. Downey, moving to the topic that relates to the entities that

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supplied or have supplied talc to J&J for its talcum-powder products -- and I put a document in front of you and I've marked it as Exhibit 9. And it's Imerys Bates number 428014.

Have you seen this document before?

A. Yes.

Q. And when's the first -- when did you first have an opportunity to review this document?

A. I think January of this year.

Q. For what purpose did you review it?

A. For the case in New Jersey.

Q. For the Lanzo trial?

A. Yes.

Q. Okay. Where you provided testimony as a corporate representative of Imerys, true?

A. Yes.

Q. And a couple of questions.

First, is it your general understanding that talc for J&J's talcum-powder products was mined or sourced from the Hammondsville Mine from the 1960s pretty much until Argonaut came online in the 1990s?

MR. PROST: Object to form; outside the scope.

A. I don't recall how far back it predates,

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but Hammondsville was an active mine and an approved source in 1989 when Cyprus Mines purchased Windsor Minerals. And it operated for just a couple years after that Cyprus.

Q. (By Ms. O'Dell) And in 1989 when Cyprus purchased Windsor Minerals -- and that's the purchase agreement that we have in front of us is Exhibit 9.

At that time, Cyprus also owned a mine in Italy, right? The Val Chisone Mine?

MR. PROST: Outside the scope.

A. Are you saying that Cyprus owned that?

Q. (By Ms. O'Dell) Yes.

A. No, I don't think so.

Q. Don't think so?

A. No.

Q. And I could be -- I could be incorrect about the time frame.

But they did own a processing plant, a talc-processing plant, in South Plainfield, New Jersey, at the time they purchased Windsor Minerals, right?

MR. PROST: Outside the scope.

Q. (By Ms. O'Dell) You testified to that in your testimony at Lanzo, correct?

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A. Well, I -- yes, they owned the South Plainfield plant. I just don't recall when this plant closed.

Q. And that was the plant where asbestos was found, true?

MR. PROST: Object to form; outside the scope.

A. What do you mean?

Q. (By Ms. O'Dell) Well, when it was inspected by regulatory agencies, asbestos was found, true?

MR. PROST: Same objections.

A. That's not quite my understanding. There was some air monitoring that had been done.

Q. (By Ms. O'Dell) Did you finish your answer?

A. Well, without recalling the specific document, I didn't review Lanzo in preparation for this.

Q. Do you recall that you testified that the Mine Safety and Health, MSHA for short, went into the South Plainfield facility in 1980, inspected and determined that there was asbestos in talc? Do you recall that testimony?

MR. PROST: Object to form.

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A. I don't recall that being my testimony.

Q. (By Ms. O'Dell) You don't?

A. No.

Q. What was your testimony?

A. If you have it there, we can read it back. I generally recall testimony about air monitoring of the employees at South Plainfield.

Q. And you don't recall them finding asbestos being present in talc?

MR. PROST: Object to form.

A. There may have been more than one document that we discussed, and I would need to see the document to see if that refreshes my recollection.

Q. (By Ms. O'Dell) We'll pull that up. And let me get my colleague, if she would do that for me. And to save time, let's look at the Exhibit 9, the purchase agreement between Windsor Minerals and Cyprus Mines Corporation.

A. Exhibit 9?

Q. I'm sorry?

A. Exhibit 9?

Q. Yes, Exhibit 9.

Cyprus purchased the mines and the assets essentially owned by West Windsor.

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And those included the mines at Vermont as well as the processing plants, true?

MR. PROST: Object to form.

A. Generally speaking, yes, but when you say "the mines in Vermont," which mines are you talking about?

Q. (By Ms. O'Dell) Okay. Here's a list here in the document. And why don't we go through it in an orderly fashion. Let's get your general knowledge. If you'll go to the first tab, you'll see that it's --

A. Time out. I'm a little bit tangled up in the wire here. All right. There we go.

Q. Okay. If you'll go to 8.5, which is tabbed for you in this -- 8.5 is a subsection of the document. And it's tabbed for you there with one of the stickies; do you see that?

MR. LOCKE: Sorry. I'm just trying to see the -- what exhibit is. I don't want --

MS. O'DELL: Do you need the Bates?

MR. LOCKE: I wasn't able to pull it up right now. Okay. Thanks.

Q. (By Ms. O'Dell) This section relates to a Talc Supply Agreement between Cyprus and J&J.

And is it your understanding that a

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principal part of this transaction was that there would be a supply agreement for Cyprus to supply talc to Johnson & Johnson for its talcum-powder products?
MR. PROST: Object to form; outside the scope.
A. Yes, that's my understanding. And the supply agreement is part of the document.
Q. (By Ms. O'Dell) And when you turn over further, Mr. Downey, you'll get to a section 11.2; do you see that?
A. Yes.
Q. And this is an indemnification section. And this represents J&J will hereby indemnify and hold harmless Cyprus. And if you look further, you'll see that it includes product-liability actions; is that your understanding?
MR. PROST: Objection.
MR. SILVER: Objection. At this point, I'm going to -- unless I can get a proffer from counsel, I'm going to instruct the witness not to answer. Beyond the scope.
MS. O'DELL: It's in the document. It's a document he reviewed for purposes of responding to our scope in the discussions -- or questions about

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the entities that sold talc to Johnson & Johnson.
MR. SILVER: That question, though, has nothing to do the with the topics he's here for. And indemnification doesn't have anything to do with general causation.
MS. O'DELL: So you're instructing him not to --
MR. SILVER: I'm instructing him not to answer.
MS. O'DELL: Okay. Are you instructing him not to answer on behalf of the corporation or are you instructing him not to answer in his personal capacity?
MR. PROST: I'm instructing him not to answer across the board. He's not here in his personal capacity, so I guess it's in his 30(b)(6) capacity.
Q. (By Ms. O'Dell) Have you read that section before, Mr. Downey?
MR. SILVER: You can answer the question asked of you. Have you ever read the section?
A. I've read it before, parts of it.
Q. (By Ms. O'Dell) And it refers to -- regardless of what it means, it refers to J&J indemnifying Cyprus?

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MR. SILVER: Objection.
I'm instructing the witness not to answer.
Q. (By Ms. O'Dell) True?
Turn over to the next tab, sir, and you'll see it's on page D2; do you see that?
A. D what?
Q. D2 is at the bottom of the page. I think you're on the right page, sir.
A. That's a 6.
Q. Okay. Well, are you on the page that starts "West Windsor" at the top?
A. No, I'm on page D6. That's the one that's flagged, the next one that's flagged.
Q. I'm sorry, then, we missed a flag. If you'll go back to D2. It lists the mines that were sold as a result of this agreement; do you see that?
A. Mine says, "Financially Active Assets."
Q. Let's see if I can help here. It says, "Windsor Financial Active Assets." Okay. So we're in the -- and it says, "Year of ACO." And then it says, "Department Description or Reserves." At the bottom it says D2. Is that the right page? Do you mind if I look to see what you're looking at? Yeah, we're on the same page. It says "D2."

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A. Sure.
Q. Are these a list of the mines conveyed as a part of this purchase agreement, at least in part? Do you see the Hammondsville Mine?
A. I see where it says "Hammondsville Mine," yes.
Q. Well, let me just stop right here, because you reviewed this agreement, right?
A. Pardon?
Q. You've reviewed this agreement?
A. It's a lengthy agreement. I reviewed it about eight months ago.
Q. Okay. Well --
A. And I didn't review it in its entirety. It's quite long.
Q. What mines were purchased in Vermont as a result of this purchase agreement between Cyprus and Windsor?
MR. SILVER: Objection. Again, outside the scope.
MS. O'DELL: Why is it outside the scope?
MR. SILVER: We're not doing a -- this -- these -- the topics that you identified that you believe -- doesn't have anything to do with the history of ownership with respect to use -- the

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topic says, and I quote, 2A, "The identity, locations and owners of the source mines for Imerys or its predecessor talc sold or supplied."

We're not talking about the identities and locations. We're talking about ownership interests.

MS. O'DELL: Well, right. I'm asking him -- this is Cyprus purchasing the mines from Windsor. And I'm asking him -- he says he's reviewed the documents -- what mines were purchased? That's all I want to know. I mean, I'm not trying to be tricky. I'm not trying to, you know, be difficult. So if there's an issue that I'm not understanding --

MR. PROST: I think the key part of 2A is the "identity locations of mines that were used to source J&J talcum powder." He's prepared to do that. He's not prepared to tell you what total mines may have been purchased --

MS. O'DELL: Okay.

MR. PROST: -- for the company.

MS. O'DELL: Well, that's fair.

Q. (By Ms. O'Dell) I don't really care about some of the others as much as I'm trying to establish that this document, dated in 1989 --

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correct?

A. Yes.

Q. -- conveyed from Windsor to Cyprus certain mines that ultimately sourced J&J talc.

Is that your understanding?

MR. SILVER: We don't have any problems with that. That's not my objection. If you would either -- if that's where you're going, then I don't have any problems with it.

MS. O'DELL: That's where I'm going.

MR. SILVER: Okay.

Q. (By Ms. O'Dell) True?

A. Yes. The mines that -- if it's found in the document, but my understanding is Hammondsville, Argonaut and Rainbow were the mines that Cyprus Mines acquired from -- or acquired when they acquired Windsor Minerals.

Q. Is it also your --

A. And -- sorry. And just to be clear, the mines that were approved sources, depending on time frame, for the talc used for Johnson & Johnson products.

Q. Also Hamm was a mine that was purchased by Cyprus and was used as a source for J&J talc, true?

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A. Almost. Hamm was purchased from a different company.

Q. Okay. What company?

A. Omya.

Q. All right. When was the Hamm Mine purchased by Omya?

A. 1988.

Q. So it's your understanding that Cyprus purchased the Hamm Mine in 1988 from Omya, and in 1989 they purchased -- Cyprus purchased Hammondsville, Argonaut and Rainbow?

A. Yes. Of the mines that eventually were approved sources, or at various times were approved sources for Johnson & Johnson products, those were the mines that were acquired in 1988 and 1989 from Omya and Windsor Minerals respectively.

Q. Okay. All right. Fair enough.

And we've already agreed that part of this agreement, this purchase agreement, between Windsor and Cyprus was a stock supply agreement between Cyprus and Johnson & Johnson, fair?

A. Yes.

Q. And if you turn further, you'll see that I've made it a part of the exhibit the Talc Supply Agreement. And if you'll turn over to the first

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sticky there in the Talc Supply Agreement, you'll see there's a section 3(a).

MR. PROST: If you could hold on a second, I'm just trying to find it.

MS. O'DELL: Yeah. Sure.

Q. (By Ms. O'Dell) And it's page 5 of the Talc Supply Agreement. Are you there, Mr. Downey?

A. Yeah.

MS. O'DELL: Mark, it's page 5. It's further back in the document. It's very early in the Talc Supply Agreement.

MR. PROST: Okay. I see. I got it.

Q. (By Ms. O'Dell) And my point in asking about this, really, is to establish this: This supply agreement between Cyprus and Johnson & Johnson was such that the buyer, in other words, Johnson & Johnson, agreed to buy a hundred percent of their talc from Cyprus?

A. For the first five years, and then in the next five years, it was not less than 98 percent.

Q. And if you'll turn to, really, the exhibit, you'll see page E.1 of the document. This is the quality standards that were part of the supply agreement, correct?

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A. Yes.
Q. And it states, in subsection 1, "Johnson & Johnson is currently and must continue to be asbestos-free as defined from time to time by appropriate governmental agencies in the Cosmetic, Toiletries, and Fragrance Association (CTFA)."
Is that your understanding?
A. That's what it says, yes.
Q. And that's consistent with your understanding?
A. Yeah.
Q. And if you'll look down to 3, it says, "The Hammondsville and Argonaut ore bodies are approved for carefully controlled selected mining for ore to [sic] use in preparation of grade 66 talc," correct?
A. "For ore for use," but, yes, that's correct.
Q. And grade 66 talc is Johnson & Johnson's Baby Powder and Shower to Shower talc, correct?
A. Grade 66 is the talc product that we manufacture for Johnson & Johnson.
Q. And if you'll turn over to the next page, the agreement requires that the shipments "may only be made from silos whose contents," and

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if you'll gown to subsection B, "have been tested for conformance to specifications through the use of test methods and techniques provided and detailed by BPC as referenced in talc specifications above."
In other words, to sum it all up, there were very specific specifications that J&J required to be met by all talc that was sold to it, correct?
A. Yes.
Q. And those specifications were part of the purchase agreement -- or the supply agreement, excuse me, true?
A. Yes, they were.
Q. And if you'll turn over to -- it's E5. These are at least page 1 of the specifications and requirements; is that correct?
A. E5?
Q. Yes.
A. It says "Page 2" on the header.
Q. At the bottom it says "E5," and the page is entitled "Description: Properties and Requirements"; do you see that?
A. Yes.
Q. And these are the specifications that Cyprus was required to comply with regarding the

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talc supplied to J&J, correct?
A. Yes.
Q. And in relation to asbestos, the standard was "None detected."
Asbestos is defined to be the fibrous serpentine chrysotile and the fibrous forms of the amphibole group as represented by amosite, anthophyllite, crocidolite, tremolite and actinolite; is that correct?
A. Yes.
Q. And if you'll go down further, in terms of heavy metals, the specification was there could be no more than 10 parts per million, true?
A. It says "NMT 10 PBM." That's my understanding.
Q. "NMT" means no more than?
A. That's my understanding, yes.
Q. And as to arsenic, the standard, in other words, the talc could have no more than 2 parts per million, true, in order to be compliant with J&J's specifications?
A. Yes.
Q. And if talc supplied by Cyprus to J&J had, for example, fibrous serpentine, that product would be out of specifications, true?

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A. Yes.
Q. And it would be, in essence, defective in comparison to the specifications required by Johnson & Johnson?
MR. PROST: Object to form.
A. It would be out of specification. I don't know what you mean by "defective."
Q. (By Ms. O'Dell) Okay. Same would be true if arsenic was at a level in the talc provided to J&J at a rate more than two parts per million. That would be out of specification?
A. Yes.
Q. Let me have you turn over about three pages. And there's a -- maybe one more, Mr. Downey. There's a material safety data sheet. There you go. You'll see that. It's a material safety data sheet that was part of the contract, supply contract, between Cyprus and J&J.
And you see it's dated September 13, 1985?
A. Looking for the date.
Q. It's in the upper portion of the document.
A. Oh, I see it. Okay.
Q. "Date Issued." It says, "Trade name and synonym grade 66 talc," right? That's J&J talc,

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true?
A. Yes.
Q. And the material safety data sheet says, "Note"; do you see that? "Does not contain asbestiform minerals and contains less than 1 percent crystalline silica"; did I read that correctly?
A. Yes.
Q. So on the material safety data sheet provided by Cyprus to Johnson & Johnson, it stated there were no -- that the talc does not contain asbestiform minerals, true?
A. No.
Q. Okay. Why is that not true?
A. This is the material safety data sheet of Windsor Minerals dated 1985. That wasn't a Cyprus product at that time.
Q. Did you make it a part of the material safety data sheet -- did Cyprus make that a part of the materials they provided to Johnson & Johnson when they shipped talc?
A. Cyprus would have updated the material safety data sheet so that it would have been issued from them, I would expect, but your question was specifically about this document that was dated in

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1985, and I just wanted to make sure that the record was clear.
Q. That's fair.
Have you seen the Cyprus version of this material safety data sheet for grade 66 talc?
A. I don't recall.
Q. At least on this MSDS sheet, the statement is that the product does not contain asbestiform minerals, correct?
A. That's what it says.
Q. All right. So Cyprus bought Windsor and Argonaut and Hammondsville and Rainbow in 1989. We've already established that --
A. Slow down. I just want to catalog to make sure that I'm following. So you said?
Q. Mr. Downey, nobody ever tells me to slow down, I talk so slow. So that's a once-in-a-lifetime. But I will slow down. So I'm just wrapping up.
So this document was a purchase agreement for Cyprus to buy Windsor Minerals, that part of that transaction was the purchase of the Hammondsville, Argonaut and Rainbow mines?
A. Yes.
Q. And prior to that agreement in 1989,

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Cyprus had already purchased the Hamm Mine in 1988, true?
A. Yes. That's what I said.
Q. And then, in 1992, Rio Tinto Minerals, RTM for short, purchased Cyprus?
A. RT -- RTZ America purchased Cyprus Talc Corp. in 1992.
Q. Okay. Let me show you what I'm marking as Exhibit Number 10.
(Exhibit 10 was marked for identification.)
MS. O'DELL: And there are Bates numbers. I've got one more. Exhibit 10 is Bates-numbered Imerys-MDL-AB-0008412.
Q. (By Ms. O'Dell) Mr. Downey, have you seen this document before?
A. Yes, or various portions of it.
Q. I will represent to you that the total documents, about 900 pages -- and I have culled it down to the most relevant portions.
A. I appreciate that.
Q. Yeah.
A. What page are you on?
Q. It was just a prefatory question. I was just looking at the -- I was looking, actually, at page 3 of the document. You're welcome to turn

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there, but I was just going to ask you a general question, because I'm going to draw an objection from your counsel if I ask about any of the business aspects of it.
So the question, I really want to say generally, is this was a stock purchase between Cyprus Mines Corporation, Cyprus Minerals and RTZ America, Inc., true?
A. Cyprus Minerals Company, if you want to read the whole thing. The reason I'm trying to be clear is that there are so many Cyprus entities, I just want to make sure we know what we're talking about Cyprus.
Q. Well, the document says -- I'm not fussing with you, this says "Cyprus Mines Corporation and Cyprus Minerals Corporation," so I don't want to talk at cross-purposes. I'm not looking beyond that. I'm just telling you that's what this document is. And it's a stock purchase agreement between those companies, those Cyprus companies, and RTZ.
A. Again, for clarity, I believe it's Cyprus Mines Corporation and Cyprus Minerals Company, not corporation. I'm just trying to make sure we're clear.

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MR. SILVER: Yeah. Leigh, I don't think -- just -- so the witness is, I think, looking at the table of contents, and I think that's where he's getting it from. I don't know what page you were reading off, so that's . . .

MS. O'DELL: Okay.

A. It's the same on the cover page as well.

Q. (By Ms. O'Dell) Okay. I -- I mean, it's really -- I was trying to read that. If I read it incorrectly, I didn't mean to. So it's Cyprus Mines Corporation, Cyprus Minerals Company, sold stock, all the stock, of those corporations to RTZ America essentially transferring ownership interest in all the mines that had been sourcing J&J talc which we've established were Hammondsville, which was the initial mine, Hamm, Rainbow, Argonaut.

Those assets were transferred with this agreement through a stock purchase to RTZ America, Inc.?

MR. PROST: Object to form.

A. The document will speak for itself. There were parts of the Hamm property that were left behind.

Q. (By Ms. O'Dell) But the Hamm Mine

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itself was a part of the agreement that resulted in ownership being transferred to Rio Tinto?

MR. PROST: Object to form.

A. There were two Hamm mines. That's why I'm trying to be clear. The Hamm underground mine did not transfer in this transaction. The Hamm open pit did.

Q. (By Ms. O'Dell) Let's get more basic.

RTZ America is Rio Tinto. Let's make sure that's clear on the record.

A. RTZ is Rio Tinto Zinc. That's what it stood for.

Q. Let me ask you to turn to Bates number 9025, "Schedule 5.16 Environmental Information."

A. I'm sorry. 90?

Q. 9025.

A. 25.

Q. Do you see that, sir?

A. I'm there. Yes.

Q. And so this was environmental information that was made a part of the stock purchase agreement, correct?

A. Yes.

Q. Okay. And so if you'll turn over two

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pages, it has due diligence regarding Vermont talc; do you see that?

A. Can you give me a hint on where it's at?

Q. Yeah.

A. 9027?

Q. Yeah. 9027. Yup.

A. Okay. What . . .

Q. The upper third of the page, you see April 11, 1988.

A. Okay.

Q. "Due diligence on Vermont talc," do you see that?

A. Yes.

Q. And so this is information about the mines owned at that time by Cyprus providing due-diligence information to Rio Tinto as part of this purchase agreement, correct?

A. More specifically, these were Rio due-diligence documents that Cyprus had prepared in 1988 in advance of their purchase of the Vermont Talc Company.

Q. And these were -- this was -- these were documents -- this document was made a part of the purchase agreement between Rio Tinto and Cyprus?

MR. PROST: Object to form.

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A. It was included in the document, yes.

Q. (By Ms. O'Dell) Yes. And this document, if you'll look down at the bottom, refers to the Hamm Mine; do you see that?

A. Yes.

Q. And this states -- and this is Cyprus, as you point out, writing this -- "Will require selective mining to avoid actinolite and to control arsenic levels."

That was part of the information that was conveyed to Rio Tinto, true?

MR. PROST: Object to form.

A. It was information conveyed to Rio Tinto, and the source of the information and the date is 1988.

Q. (By Ms. O'Dell) Okay. Now, turn over to page 6. And it's Bates number -- excuse me -- 9030.

A. 30?

Q. Yeah. 9030. Do you see that?

A. I'm there. Yes.

Q. It says October -- dated October 19th, 1988.

A. Okay.

Q. It says, "Hammondsville Mine:

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Amphiboles in hanging and foot walls"; do you see that?
A. Yes.
Q. "Rainbow Mine: Elevated levels of amphiboles"; do you see that?
A. Yes.
Q. "Argonaut Mine: Amphiboles in hanging walls."
A. "Hanging wall."
Q. Excuse me. Didn't mean to put an "s" on there. "Hanging wall."
All right. Did I read those correctly?
A. Yes.
Q. And that was information provided to Rio Tinto as a part of this purchase agreement, correct?
A. Yes.
Q. You can put that aside, Mr. Downey.
So in 1992, Rio Tinto purchased Cyprus Mineral Company and Cyprus -- hang on, I'll get it right -- Cyprus Mines Corporation and Cyprus Minerals Company?
A. No.
Q. I just read it from the document.
A. You said that Rio Tinto purchased Cyprus

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Mines Corp. and Cyprus Minerals Company. No, they didn't.
Q. Okay. All right. How'd I get the transaction wrong, then? They purchased the stock?
A. They purchased the stock of Cyprus Talc Corporation. The document -- I can give you a synopsis of it, but the document speaks for itself. In 1992, for the purpose of selling the talc business, Cyprus Mines Corporation took its then-existing talc business and formed a new corporation called Cyprus Talc Corporation. And it put the talc business into Cyprus Talc Corp. And it was that entity, Cyprus Talc Corporation, that Cyprus Mines Corp. and Cyprus Minerals Company sold to RTZ America except for the portion of the Hamm property that was left behind.
Q. And in regard to the portion of the Hamm property that went with the sale -- so a portion of the Hamm was left behind --
A. Okay. Yeah.
Q. -- and a portion went with the sale?
A. Right.
Q. And the portion that went with the sale was the portion with the mine?
A. Again, there were two Hamm mines. It

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was the Hamm open-pit mine that went with the transaction.
Q. That's fair. That's fair.
A. It was the Hamm underground mine that was left behind.
Q. Yeah, that's fair. That's what I was trying to convey. I mean, because, clearly, Rio Tinto purchased the Hamm open-pit mine and, indeed, after that transaction, extracted talc ore that was then sold to Johnson & Johnson, true?
MR. PROST: Object to form.
A. That acquisition was in 1992.
Q. (By Ms. O'Dell) Yes.
A. The Hamm Mine was eventually approved as a source for Johnson & Johnson product, I believe it was, like, September of 1990. There are documents that show when that happened. And I don't recall how long Hamm was used as a source, you know, if it continued after 1992, so I'm -- the -- we can find it in the documents, but I'm just trying to make clear, because Hamm was used for a limited period of time, and then by, like, 1994, Argonaut was the sole source. That's my understanding.
Q. Okay. I think the timeline's a little

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bit different in the documents. But you and I basically agree, Hamm was a source for J&J talc --
A. Oh, it's clear. Yes.
Q. And the open pit -- Hamm -- the open-pit mine was a source for --
A. Yes.
Q. -- J&J talc.
Following Rio Tinto's purchase of Cyprus Talc Corporation in '92, the name of the corporation was changed to Luzenac America, Inc., correct?
A. Shortly after the transaction, Cyprus Talc Corporation, that was that newly created corporation about to convey the talc business -- or to sell it, that was renamed Luzenac America, Inc.
Q. And what began as Cyprus and then transitioned to RTZ America and then to Luzenac America, Inc., those corporations, from 1989 until 2003, sold talc mined in Vermont to J&J for purposes of their Baby Powder products?
MR. PROST: Object to form.
A. Based on time frame -- when you say "Cyprus," I just need to be clear, because there's so many different Cyprus entities, and I don't want to make a mistake on the record.

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It's my understanding that, beginning in 1989, Cyprus Mines, through its acquisition of Windsor Minerals, supplied grade 66 to Johnson & Johnson -- just a minute -- until Cyprus Mines Corp. sold off the talc business to Rio Tinto in 1992. Then in 1992, as part of that acquisition, Luzenac America sold grade 25 to Johnson & Johnson from '92 until 2003 from Vermont.

Q. Yes.

A. Or from the mines we discussed in Vermont.

Q. And as a part of Rio Tinto's due-diligence process prior to the stock purchase of Cyprus Talc, Cyprus provided information to Rio Tinto about the ore bodies involved in the Vermont mines as well as information about ore reserves, et cetera?

MR. PROST: Outside the scope.

Q. (By Ms. O'Dell) And that was all a part of the due-diligence process, true?

A. Due diligence is a multi-faceted process to understand the nature of the business. And there are lots of types of documents and information that's exchanged between the corporations in regard to that due-diligence

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process.

Q. Certainly, information about ore reserves would be something that a company would be very interested in prior to purchasing a mine, true?

MR. PROST: Object to form.

A. Yeah. The ore reserves are important.

Q. (By Ms. O'Dell) That's right. Hugely important, because that's how you evaluate the worth of that particular asset, true?

A. It's one of the components that you -- that helps establish the value.

Q. It's an important component?

A. It's one of many important components.

Q. Well, there's no -- if you're in the mining business and there's no ore to be mined, you don't want to purchase the mine, in most situations, true?

A. Generally speaking, I'd agree with that.

Q. Yeah.

(Exhibit 11 was marked for identification.)

Q. (By Ms. O'Dell) Let me hand you what I've marked as Exhibit 11. It's a document entitled "Cyprus Ore Reserve Evaluation Preliminary Summary" by R.C. Munro.

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MR. PROST: If we could just say the Bates number?

MS. O'DELL: Yeah. Thanks, Mark. Happy to. Imerys 425354.

Q. (By Ms. O'Dell) Have you seen this document before?

A. Yes. It's been a while, but yes.

Q. And if you'll look at the introduction of the document, Mr. Downey, you'll see it says --

A. Can you hold a second?

Q. Sure.

A. (Document reviewed.) I may have misspoke. In the past, I've seen a document from R.C. Munro that, at least on the first page, I thought was familiar, but as I look in the document, this -- this might be a different document.

Q. Okay.

A. Sorry about that.

Q. Yeah. No problem. But this is a document produced by Imerys in the production for the litigation, correct?

A. Yes. It has an Imerys Bates reference.

Q. Would -- an ore reserve evaluation would be something that would be kept by a mining company

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in the normal course of business?

A. It's a document that is contained in Imerys' files. This particular one, though, I think was a third-party document, and I don't remember its progeny, or its source. I know it was in our files, but I don't know if it was a company document.

Q. That's really all -- that's what I'm asking. Is it something that would be maintained in the normal course of business?

So this is a Cyprus -- this is information that's being given by Cyprus in advance of the Rio Tinto transaction. If you look, it says, "A complete evaluation of CIM talc reserves is underway."

MR. PROST: Object to form.

A. This is --

Q. (By Ms. O'Dell) Did I read that correctly, sir? That was my question.

A. Well, you characterized it as information provided by Cyprus. This isn't a Cyprus report.

Q. Okay. Let me go down further.

Is it your position that this is a document that was generated by Rio Tinto?

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A. I don't know who it was generated by other than the author is shown as R.C. Munro. I don't recall -- other than his name being on the document, I don't know who he worked for, but it's my general understanding, based on seeing it in the past, I think it was some sort of external review.
Q. Well, the complete evaluation is "CIM talc reserves, and I believe that to mean Cyprus talc reserves, "is underway."
And if you'll look in the first paragraph, it says (as read:) Two USB senior geologists have been conscripted part-time for independent reserve calculations on the important talc deposits.
Then further, it says (as read:) We've been working with Philippe Moreau of Talc Luzenac, Ernie Reade of CIM and the CIM geological staff; did I read that correctly?
MR. PROST: Object to form.
A. Parts of it. I think you skipped a word in the upper one, and you skipped over some things.
Q. (By Ms. O'Dell) I didn't intend to read every word, but what I read, I read correctly, fair?
A. You skipped over some words and some other things, but what you read was correct.

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Q. All right. Philippe Moreau is an employee of Talc Luzenac. Philippe Moreau currently is an employee of Imerys Europe, correct?
A. I have no idea.
Q. Have you heard that name before?
A. Only in a document like this.
Q. And you understand that he was a senior geologist for Luzenac, correct?
A. I don't know.
Q. Okay. Let me ask you to turn to page 2 of the document. Let's see if I can get it on the screen correctly.
It says -- it's referring to Hammondsville. And that's the Hammondsville Mine, the underground mine we referred to earlier, true?
A. Yes.
Q. "Hammondsville and Beaverhead appear to have no significant economic value as reserves."
Then it talks about the Troy deposit. "The usable tonnage at the Troy deposit is substantially reduced."
A. The what? Did you say "unusual"?
Q. No, I didn't. "Usable."
A. Oh, okay. I'm sorry. My hearing isn't the best. I apologize.

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Q. It says, "The Hamm deposit needs more detailed study before its future value is understood. Significant additional potential may exist at Argonaut"; do you see that?
A. Yes.
Q. So this is a document that's evaluating Hammondsville. It's evaluating Hamm. It's evaluating Argonaut, all three mines that sourced J&J talc, true?
MR. PROST: Object to form.
A. This is a document that indicates that the review is ongoing.
Q. (By Ms. O'Dell) That's not my question, sir.
I'm asking you, this is -- these -- the review covers the three of the four mines that you and I have agreed were sources of talc for J&J Baby Powder and Shower to Shower; is that correct?
MR. PROST: Object to form and foundation.
A. It includes those mines, yes.
Q. (By Ms. O'Dell) Yes. And it says, you'll look further down, "Some problems with several of the mine reserve sites have emerged. Fibrous minerals - tremolite and actinolite are ubiquitous in several zones of the Vermont mines.

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The potential problems involved with fibre in dumps, and to some degree in products, must be carefully evaluated"; did I read that correctly?
A. Yes.
Q. If you'll turn over to page 4, at the top of the page, it says, "Arsenic minerals, both insoluble sulfides and the more soluble arsenate minerals are problems that restrict productivity in an effort to keep product under 3 parts per million soluble as in the West Windsor and Johnson Mills."
West Windsor is the mill that processed J&J's talc, correct?
A. Yes.
Q. You'll turn over to page 23 of the document, do you see it's discussing Vermont? Okay.
Talks about two dry mills, two flotation plants, five mines at the three Vermont locations.
And then it goes down to say -- and it's talking about mineralogy. It says, "The area containing these reserves is all within the Appalachian Ultramafic Belt that trends north-south through the state. In certain areas, these ultramafics host talc carbonate rock developed by the alteration of serpentine bodies," correct?

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A. That's what it says.
Q. And that's consistent with the discussion you and I had earlier, though we disagree about what type of ultramafic rock may have been involved, fair?
A. Generally, yes.
Q. If you'll turn over to page 24, it says, (as read:) Talc alteration typically is strongest at the outer borders of the talc bodies and decreases gradationally inwards terminating rather abruptly at the boundaries of the non-altered talc serpentinite; did I read that correctly?
A. No.
Q. Okay. What'd I get wrong?
A. You inserted the word "talc" before "serpentinite."
Q. Okay. "Talc alteration typically is strongest at the outer borders of the talc bodies and decreases gradationally inwards terminating rather abruptly at the boundaries of non-altered serpentinite"; did I read that correctly now?
A. Yes, you did.
Q. "Within the talc bodies are found discontinuous bed-like lenticular bodies of chlorite and amphibole minerals, termed locally as

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'cinders,' see sketch," and there's a sketch below, all right? Do you see that?
A. Yes.
Q. And so according to Mr. Munro, chlorite and amphibole minerals compose what are termed locally there in Vermont, I'm assuming, as cinders, correct?
MR. PROST: Object to form.
A. That's what it says.
Q. (By Ms. O'Dell) And we would agree, Mr. Downey, that amphibole minerals can be asbestos, such as tremolite, actinolite and other types of amphiboles, true?
A. Generally speaking, amphiboles is a very broad family of minerals that are quite common in the earth's crust.
Q. That's not my question. I move to strike the answer.
I'm just asking if asbestos that I listed, tremolite, actinolite being two, are also part of the amphibole minerals.
MR. PROST: Object to form.
Q. (By Ms. O'Dell) True?
A. Tremolite and actinolite are amphibole minerals, yes. They occur --

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Q. Okay. Yes. All right. Cool.
MR. PROST: I think he's not finished with his response. I'd like to let him finish.
Q. (By Ms. O'Dell) You may finish, Mr. Downey, but -- and I want to be fair to you. You can finish your answer, but it'll just be easier if you'll answer my question when it's a very clear answer, a very clear-cut question like that. So you may finish.
MR. PROST: Well, I think he can answer to the extent he thinks he needs to to honestly answer the question.
So go ahead, Pat, if you'd like, to continue what you were saying.
A. Tremolite and actinolite are amphibole minerals. Their most common occurrence is in the nonasbestos variety. Their occurrence in the asbestos variety as tremolite asbestos or actinolite asbestos is actually rare.
Q. (By Ms. O'Dell) Okay. Thank you for your answer.
MS. O'DELL: Counsel, just so you know, that response -- I didn't ask if they were rare. I didn't ask how common they were. Didn't ask any of those questions. So to be fair to me, I'm just

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asking you to instruct your client -- he can answer my question. I'm going to give him a chance, and I'm going to be very cordial, but he should answer my question and . . .
MR. PROST: Sometimes I think a question can't be answered with a simple yes or no, the way you want it to be answered. And so I think the witness was honestly trying to answer it in a way that gave it full and honest context. So I'm going to say -- I'm not going to tell him to limit his response if he feels like he needs to answer it honestly. I'm not saying to not answer the --
MS. O'DELL: If I have to ask the question -- to be fair, if I ask the question if actinolite and tremolite asbestos are amphibole minerals, that's an easy "yes." I'm not being tricky. That's an easy "yes." So anyway, let's -- I'll move on.
MR. PROST: Well, that's fair, but I think you asked him a different question than that, but you're right. Let's go on.
Q. (By Ms. O'Dell) Okay. This is a sketch --
THE WITNESS: Can you just refill my water?
MR. PROST: Sure.

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Q. (By Ms. O'Dell) -- of part of the -- of sort of a rough sketch, it looks like, of a talc deposit in Vermont; do you see that? And it's depicting schist, right, sort of on the outer walls here? That's schist, right, as you see? And I'm doing a poor job with my highlighter coloring, but what I've marked is schist, correct?

A. Can you blow it up?

Q. Yeah. Better? Fair? That's what -- what I've colored is schist, right?

MR. PROST: Object to form; foundation, with this sketch.

A. This, I think, is the first time I've seen the sketch. It lists schist on the edges. It doesn't have any arrows, you know, pointing over there to the zones like he does for other examples, so I don't know.

Q. (By Ms. O'Dell) All right. Fair enough.

They go on to talk about the "deleterious minerals present in the bodies" at the bottom of the page; do you see that?

"Deleterious minerals present in the bodies" -- and we're talking about Vermont talc ore bodies -- "include arsenic sulphides, metallic

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arsenates, iron and fibrous minerals, principally tremolite and actinolite"; did I read that correctly?

A. Yes.

Q. And so the amphibole minerals that are present -- some of the deleterious source of the amphibole minerals present are fibrous tremolite and actinolite. And those are asbestos, correct?

MR. PROST: Object to form.

A. That's not my understanding.

Q. (By Ms. O'Dell) Fibrous tremolite and fibrous actinolite are considered asbestos, true?

MR. PROST: Object to form.

A. Not always.

Q. (By Ms. O'Dell) When they're fibrous, they are generally considered to be asbestos, fair?

MR. PROST: Object to form.

A. The inclusion of the word "fiber" or "fibrous" in the definition of what was asbestos, it led to a lot of ambiguities and misunderstanding between geologists and mineralogists and others. And by itself, "fibrous," without other morphological mineral logic criteria, doesn't add meaning to the description.

MS. O'DELL: Move to strike as

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nonresponsive.

Q. (By Ms. O'Dell) Fibrous tremolite is considered to be an asbestiform mineral, true?

MR. PROST: Object to form. And I think his answer was responsive. This move to strike as nonresponsive, as my understanding of the deposition guidelines, is not a proper thing to say at the deposition.

Q. (By Ms. O'Dell) True, Mr. Downey?

A. I forgot your question. I'm sorry.

Q. Okay. I'll go back.

Fibrous tremolite is considered to be an asbestiform mineral, true?

MR. PROST: Object to form.

A. Asbestiform, or asbestos, are the elongate flexible separable high-tensile-strength chemically and thermally resistant -- if you want to call them fibers at that point, but they need to meet morphologic characteristics, not just a definition of a fiber based on certain length or diameter criterion. For it to be asbestos, tremolite asbestos, it needs to also exhibit the morphologic characteristics that are actually asbestos.

Q. (By Ms. O'Dell) Well, assume that

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whatever characteristics you have in mind are met -- and I don't know what those are, and I'm not asking you because I'm going to ask -- or somebody on my -- on the Plaintiffs' Steering Committee will ask Miss Pier about those characteristics.

But assuming that those characteristics are met, fibrous tremolite is asbestos, true?

MR. PROST: Object to form.

Q. (By Ms. O'Dell) I'm not trying to be tricky. It's a type of asbestos. You list it on your chart in Exhibit 5. So, true?

MR. PROST: Object to form. And it's getting repetitive. You're asking him to make a blanket statement. He said he can't. He's answered the question.

MS. O'DELL: He hasn't answered my question.

MR. PROST: Well, you asked him whether fibrous tremolite was asbestiform. And he's saying not necessarily. There's all these other characteristics that he said for you. That's his answer.

MS. O'DELL: All right. Fair enough.

Q. (By Ms. O'Dell) You say not necessarily. If it says -- as fibrous tremolite, it's not necessarily asbestos; is that your

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position? That's what your counsel said. I mean, if that's a good summary, I want to know that.
A. I don't think that that's a good summary, because in order to identify it and describe it as asbestos, we need to use careful language. And if it's the asbestos variety of tremolite that exhibits those morphologic characteristics of elongate fibers that are separable, that are chemically and thermally resistant, they're fibrile bundles that are flexible, those aspects -- and Julie Pier can talk more about the morphologic characteristics, but they need to exhibit -- the mineral needs to exhibit those characteristics in order to be tremolite asbestos.
And the careful use of the language is not to just call it tremolite, but actually to say, in that form with those mineral morphologic characteristics, that habit, that that is tremolite asbestos.
Q. Okay.
MR. PROST: And when there's an appropriate to time for you, if we could take a break pretty soon. I think we've been going for a while.
MS. O'DELL: Okay. Let me get through with

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this.
Q. (By Ms. O'Dell) So in regard to the sentence I just read, it relates to the deleterious minerals present in Vermont bodies, giving it context, principally -- excuse me. Back up.
"...fibrous minerals, principally tremolite and actinolite," you're saying that's not necessarily asbestos, but it's also equally true it could be asbestos.
MR. PROST: Object to form.
Q. (By Ms. O'Dell) Fair?
A. Not with respect to. That doesn't conform with our understanding.
Q. You're saying, on behalf of Imerys categorically, there has never been tremolite asbestos in the ore deposit?
MR. PROST: Object to form.
A. Correct.
Q. (By Ms. O'Dell) Are you saying, on behalf of the company, under oath, that chrysotile asbestos has never been found at Argonaut?
MR. PROST: Object to form.
A. That's correct. That's my understanding.
Q. (By Ms. O'Dell) And would you say that

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it's also true in relation to the Hammondsville, Hamm and Rainbow mines that neither tremolite or chrysotile has been found in those mines?
MR. PROST: Object to form.
A. I'm not aware of those being found in those other mines.
Q. (By Ms. O'Dell) And in relation to the four mines that sourced J&J talc -- Hammondsville, Hamm open pit, Rainbow and Argonaut -- is it your testimony, on behalf of Imerys, that actinolite asbestos has never been found in any of those mines?
MR. PROST: Object to form.
A. That's my understanding.
Q. (By Ms. O'Dell) Okay. All right. Let me ask you to turn to page 26. We're still on Exhibit 11.
MR. PROST: Is now not a good time to take a short break?
MR. SILVER: Let her finish the document.
MR. PROST: Oh, if you want to finish the document, that's fine if you want to do that.
MS. O'DELL: Yeah. That'd be helpful if we could do that.
MR. PROST: Sure.

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Q. (By Ms. O'Dell) On page 26, at the top, it talks about "Arsenic sulphides and arsenates encapsulated in talc grains are found in varying degrees from deposit to deposit and appear to be concentrated in the structurally distributed zones, shears and fractures according to the Cyprus staff"; did I read that correctly?
A. Yes.
Q. And is that consistent with your understanding that arsenic occurred at high levels in certain portions of the mines at Vermont?
MR. PROST: Object to form.
A. Generally speaking, it's my understanding that arsenic locally could be at an elevated value, but generally speaking, the talc source for Johnson & Johnson was low arsenic ores that had been identified and designated as such.
Q. (By Ms. O'Dell) It goes on to say, (read as:) Fibrous amphiboles are noted in footwall and hanging wall zones and in grey talcs near these areas; they are found within and bordering some of the "cinder" zones and at the contact zone with serpentine; did I read that correctly?
A. That's what it says.

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Q. And the contact zone that's being referred to there, Mr. Downey, is the contact zone between serpentine and talc ore, correct?
MR. PROST: Object to form.
A. I'm not sure without spending time reading the document to understand what the author meant.
Q. (By Ms. O'Dell) Well, I'll note that cinder is located -- this is what this is saying, as I appreciate it, and correct me if I'm wrong.
Cinder is at the contact between serpentine and talc. We will look at some other maps, and that's what I understand that sentence to say.
Do you have any reason to dispute that?
MR. PROST: Object to form.
A. Not without spending time looking at more things, other things.
Q. (By Ms. O'Dell) Let me ask you to turn to page 29. And you'll see this section relates to the Hamm Mine; do you see that?
A. The bottom couple paragraphs?
Q. Yes. And it goes on to the next page. And I'll direct you to the second paragraph.
It says, "The Hamm Mine has established problems with high arsenic zones and areas with

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fibrous actinolite, but is mined for its relatively high talc content and high brightness ores"; did I read that correctly?
A. That's what it says.
Q. And if you'll go to page 32, you'll see it's referring to the Ludlow Mines. And it says, in the first paragraph, bottom, "Most" -- referring to the Ludlow mines, "Most have significant arsenic and fibre bearing areas which must be excluded."
And then it talks about the Rainbow Mine. And that's one of the mines that was used to source J&J talc, correct?
A. For a period of time, yes.
Q. And if you'll keep going further, there's a map that gives sort of a layout, it's not detailed, but a layout of generally where the mines are located.
And is this map generally consistent with your understanding, having been there several times, in terms of where the mines are generally located?
A. Generally speaking, yes.
Q. Okay.
A. I think that the East Argonaut and Main are mislabeled.

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Q. Okay. Then, if you'll turn to page 34, you'll see there's a section that relates it Argonaut. And it says, "The most important reserve on the Ludlow trend is the Argonaut where the Argonaut Main ore body open pit, a three-million-ton deposit of medium (greater than 65 to 75 GEB)" -- which that describes brightness, right?
A. Yes.
Q. -- "brightness reserve," and then it goes on to say, (as read:) has been supplanted by the development of Argonaut East ore body due to the high stripping ratio and high incidence of fiber-bearing zones encountered in the main ore body; did I read that correctly?
A. You forgot "possibly."
Q. Okay.
MR. PROST: Just to be clear on that one, would you mind reading that with the word "possibly" inserted where it was, just so it's clear?
MS. O'DELL: Yeah, yeah. I'll be happy to.
Q. (By Ms. O'Dell) Okay. I'm going to go back. This is talking about the Argonaut Main ore body and juxtaposing against the Argonaut East ore

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body, fair?
A. I haven't had time to read everything. There's a description of Argonaut Main and Argonaut East.
Q. Okay. It says, "The most important reserve on the Ludlow trend is the Argonaut where the Argonaut Main ore body open pit, a three-million-ton deposit of medium (greater than 65 to 75 GEB) brightness reserve, has been supplanted by the development of the Argonaut East ore body due to the high stripping ratio and possibly high incidence of fibre bearing zones encountered at the main ore body"; did I read that correctly now?
A. Yes.
Q. And this document, if you'll keep going further, is on page Bates number ending 389; do you see that? We don't have a date on the overall exhibit, the overall memo, that Mr. Munro wrote, but at least it's after February 14th, 1992, which is the date of the this interoffice correspondence that's attached to the memo, correct?
MR. PROST: Object to form.
A. Are you representing that this was attached to the original document?

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Q. (By Ms. O'Dell) Yes.
A. I can't tell one way or the other.
Q. So it appears that this document was one of the pieces of information that was provided to Rio Tinto as part of the sales process -- excuse me -- as part of the purchase -- stock-purchase process in 1992 or shortly thereafter.
MR. PROST: Object to form.
Q. (By Ms. O'Dell) Fair?
A. It might be dated in that time period, but, again, I don't recall who R.C. Munro worked for. I've seen a different document with his name on it in other production.
MS. O'DELL: Okay. All right. Thank you, Mr. Downey. We can take a short break.
MR. PROST: Okay. Thank you.
VIDEOGRAPHER: Off the record at 3:09.
(Recess taken.)
VIDEOGRAPHER: We're back on the record at 3:26.
Q. (By Ms. O'Dell) Mr. Downey, let me show you what I've marked as Exhibit Number 12.
(Exhibit 12 was marked for identification.)
Q. (By Ms. O'Dell) And this is a document that was produced to us in litigation. Its Bates

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number is IMERYS 219720.
Have you seen this document before?
A. I'm not sure.
Q. Did you review it in preparation for your deposition today?
A. No.
Q. And this is a memo dated March 25th, 1992, correct?
A. Yes, it is.
Q. And the author is R.C. Munro. And he's the same person -- gentleman, I suppose -- that wrote the previous exhibit we were looking at before the break, Exhibit Number -- I believe it was number 10.
A. Eleven.
Q. Eleven. Thank you.
And the title of this document, this interoffice correspondence, is "Cyprus Ore Reserves - Arsenic and Tremolite"; do you see that?
A. Yes.
Q. And this document relates to the Cyprus talc ore reserves particularly in Vermont?
A. That's what it says.
Q. And it has a -- the first section is related to arsenic. And it says, "Arsenic iron

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sulphides (arsenopyrite) are, with their alteration products, present in many of the talc-carbonate schist ore zones in the Vermont area"; did I read that correctly?
A. Yes.
Q. It says, "Total arsenic, as analyzed in the Ludlow Rainbow deposit, averages generally less than 100 parts per million but with some small zones in excess of 1000 parts per million. No apparent major effort is underway to regularly monitor or completely assess the total arsenic content of ores, tailing solids and wastes although the distribution of sulphides and arsenates in talc ore system is generally understood"; did I read that correctly?
A. That's what it says.
Q. Mr. Munro is writing to those -- his distribution list, and we have some idea of who that is. If you'll turn to page 3, it includes R.J. Kerstetter; G.L. Toll; G.B. Lawson, BCL; J. Paulsen; and P. Moreau, Talc de Luzenac. And that should be Philippe Moreau, correct?
A. It will seem so.
Q. Are you familiar with any of the other individuals listed on the distribution list?

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A. No.
Q. Mr. Munro is writing this memorandum and he's pointing out issues regarding arsenic and tremolite in the Cyprus ore reserves, correct?
A. Generally, yes. I haven't read the whole thing, so I don't know what he's saying, but that's the topic matter.
Q. And if you'll see in subsection -- excuse me, paragraph two under "Arsenic," it says, "In near surface weathering zones, crushed rock, stock piles and mine working areas, the arsenic sulphides (above) convert in part to the more soluble arsenates, for example, the hydrous nickel arsenate, annabergite," which is one of the arsenates; do you see that?
A. That's what it says.
Q. It goes on to say, "Soluble arsenic is measured in cores, ore samples, mill feed, product and tailings. Soluble arsenic content is monitored and governed under EPA/OSHA regulations," correct?
A. That's what it says, yes.
Q. And arsenic at high levels is considered to be a carcinogen by the World Health Organization, true?
A. It's my general understanding that

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arsenic has been identified as a carcinogen. I don't know at what exposure level.

Q. Turning to page 2, Mr. Munro writes, "To me, there also seems to be the overall risk of continuing conversion of arsenic in sulfide to more soluble arsenates in some stockpiles, waste, and solid tailings as acid, water, air and time work on them."

Is Mr. Munro saying that exposure of arsenic sulfide to rain, to air, to time, to acid can result in the arsenic sulfide converting into more soluble arsenates?

MR. PROST: Object to form.

A. The paragraph says what it says.

Q. (By Ms. O'Dell) Do you know that to be true, that if arsenic sulfides are exposed to rain, acid, air, then they can convert to soluble arsenic?

A. Generally speaking, it's my understanding that some sulfide minerals can become soluble, yes, but under very specific conditions.

Q. It goes on to talk about tremolite; do you see that? Are you with me, Mr. Downey?

A. Yes.

Q. He says, "The other serious

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mineralogical contaminant in the talc ores of Vermont is the fibrous variety of the amphibole minerals, tremolite and actinolite (hydrous calcium iron-magnesium silicates) which have been classified as asbestiform minerals by OSHA and EPA"; did I read that correctly?

A. Yes.

Q. Next paragraph, "As a result, all tremolite, the fibrous varieties of all amphiboles and chrysotile asbestos in talc ores are a source of great concern to all talc producers and especially to marketers of cosmetic products," true?

A. That's what it says.

Q. "Cyprus claims that there are no fibres in their cosmetic talc products and they work to rigorously ensure this. However, a recent paper published by Rutgers University worker, Alice Blount, suggests the presence of fibre in several cosmetic talcs, some of which might have come from Cyprus West Windsor material, which is a source of great concern to Cyprus management and potentially to their principal customer, Johnson & Johnson"; did I read that correctly?

A. Yes.

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Q. "Talc de Luzenac personnel are aware of the situation and Philippe Moreau is quietly working to identify the reality and magnitude of the problem."

Are you aware if Mr. Moreau provided any information about the concerns regarding the presence of tremolite in Vermont talc to Rio Tinto?

MR. PROST: Object to form.

A. I don't know.

Q. (By Ms. O'Dell) Have you seen any documents where Mr. Moreau has addressed the issue of tremolite in asbestos fibers in Vermont talc?

A. I don't recall that I've seen any documents.

Q. (As read:) Vermont talcs are derived from altered serpentine - a natural host for asbestiform minerals. There is certainly viable tremolite and actinolite in specific zones of the Vermont deposits. Fibrous tremolite was identified by the writer -- meaning Mr. Moreau -- in exposures and cores at East Argonaut and the Black Bear Mines. Cyprus staff report past tremolite from the Hammondsville and Clifton deposits; did I read that correctly?

A. Mostly.

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Q. Okay. And East Argonaut and Hammondsville mines are ones that were used to source J&J talc, true?

A. Yes.

Q. "Tremolite in these deposits is encountered in the contact zones between the talc and the surrounding schist"; did I read that correctly?

A. Yes.

Q. That goes back to the discussion we had before regarding Exhibit Number 11 in relation to contact zones between serpentines or schist and talc; do you remember that discussion?

A. I recall the discussion.

Q. It says -- and pick up the sentence -- (as read:) the surrounding schist; in the "gray talcs" in the vicinity of the contacts; and associated with the chlorite/amphibole waste zones within the talc ores that are locally termed "cinders."

So according to Mr. Munro, "chlorite/amphibole waste zones within the talc ores," that's the definition of the term "cinder"; do you see that, sir?

MR. PROST: Object to form.

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A. That's what he defined as "cinders."
Q. (By Ms. O'Dell) And he's referring to it as the local definition of "cinder," fair?
A. That's what it says.
Q. Mr. Munro goes on to talk about Montana, California and Alpine, Alabama -- very near my home -- but we don't need to talk about those, so I'm going to ask you to put that aside.
And you had never seen this document before you -- your deposition today; is that correct?
A. I don't believe I have. As I mentioned, I had seen another Munro document. Can't tell if that's the one or not.
Q. Let me show you what I'm marking as Exhibit 13, Mr. Downey and ask you if you've seen this document before.
(Exhibit 13 was marked for identification.)
A. (Document reviewed.) No, I haven't seen it.
Q. It is Bates number Imerys 436951. And it appears to be Imerys' copy of a folder. It's page 1. You'll see it says "Mine Data" on what appears to be on the tab of a folder. And you open it up and there's pictures of various mines, East Argonaut, the Argonaut Mine. These are hard to

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see, but that's -- labeled them, appears to us.
On page 2, if you keep flipping over, you'll see the view -- south view of the Argonaut Mine and aerial photo. And on page 4 of the document, the Bates number ending 54, you'll see a table there; do you see that.
A. This one?
Q. Yes. Ending in 54? Some of them look alike, so --
A. Yes.
Q. -- make sure. Okay. Great.
So this appears to be a document that provides information regarding the mines -- the Vermont mines, you know, that they provided pictures for; do you see that? East Argonaut, Argonaut Main body, Hammondsville, and so forth?
A. I'm trying to get oriented with the document, so . . .
Q. Okay. And specifically, as you're getting oriented, I'm going to ask you questions about this Ore Characteristic Summary Sheet, which appears to be a summary description of the ore body at Argonaut.
In your experience in the mining industry, over, you know, some decades, Mr. Downey, it's not

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uncommon to find summaries like this that describe the ore body of a particular mine so that it can be evaluated, business plans can take place, et cetera, fair?
A. Generally speaking, but I've not seen a document that looks like this before.
Q. Okay. Well, take a look, just for -- direct our discussion. See if I can make that a little bigger. The first sort of box there that I'm looking at on page Bates ending 54, that's "Argonaut (EOB)"; do you see that?
A. Yes.
Q. And that's East Argonaut Mine?
A. I don't know.
Q. All right. The date on it is September 1992.
It's fair to say that there was Argonaut Main body, and then there was another mine that was Argonaut East, true?
A. There was the Argonaut Main pit and the Argonaut East pit.
Q. Yes. And if you look at this and you juxtapose these two tables here, you'll see that there's -- this is EOB, and that seems to be East. And then there's Argonaut tables in the MOB, and

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that seems to be the Main body; is that a fair interpretation?
A. I don't know what "EOB" or "MOB" mean. I haven't seen those acronyms before. You're asking me to speculate on what they mean.
Q. And just so we can assure yourself that this is not a document -- this is by a third party. This is a Luzenac document. If you'll look, it says, "File: Company: Luzenac America Company" -- or it says "Company" again -- "Vermont Operations." And then it says, "Product: Talc." I don't know what it says in -- I can't see that very well in terms of what the plant is.
A. It's scratched out.
Q. Could be "Argonaut" written in, but I can't be sure of that at the moment, so -- but clearly, we're talking about Argonaut, fair?
A. The other tables say "Argonaut."
Q. And if you'll look, it says, "Ore type" in the "Summary"; do you see that? And then it says --
A. Where?
Q. In the table.
A. The left table?
Q. For "Argonaut (EOB)," yeah. I'm just

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going to move left to right, so "Argonaut (EOB)." And I'll represent to you that's east, but if you disagree with that, let me know.
"Ore type," do you see that in the table?
A. Yes.
Q. And then it also says "Associated Minerals"; do you see that?
A. Yes.
Q. And then under "Associated Minerals" for "Ore Type A" there is "Actinolite," true?
A. That's what it says.
Q. And for "Ore Type C," it says associated minerals is "serpentine"?
A. That's what it says. I don't know how to read this table, though. I'm not familiar with those ore types being named.
Q. Okay. Go down. You'll look below, "General Ore Description," "Mineralogy: Mostly talc carbonate core zone," appears to be 8 type "next to serpentine."
And if you go down further --
A. I think that's "B type."
Q. "B type"? Okay. "(B type) next to serpentine."
"Detrimental Minerals: Arsenic,"

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"actinolite."
A. "Arsenic clays actinolite."
Q. All right. We'll add "clays" in there. "Detrimental Minerals: Arsenic, clays" and "actinolite."
And if you go down further, it says "Ore Destination: Roofing, TC 100" and then "some cosmetic"; did I read that correctly?
A. That's what it says.
Q. Okay. Then we'll go over. Look at "Argonaut (MOB)," which I believe to mean the main Argonaut Mine; do you see that?
A. I see "Argonaut (MOB)," yes.
Q. And in "Argonaut Main," got "Ore Type A," "B" and "C," and you've got "Associated Minerals," and it says "Mica" and "Actinolite."
A. Yes.
Q. And below, it says, "Physical Attributes: Very hot insol," which means insolubles, right?
A. Yes.
Q. "...bright, flaky ore, generally good for all products including cosmetics," did I read that correctly?
A. Yes.

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Q. And that would include Baby Powder and Shower to Shower, true?
A. Maybe.
Q. Okay. Certainly, that was the cosmetic talc being sold from Argonaut during this time period, correct?
A. The ore for Johnson & Johnson attributes was known as 5904 ore type. I don't see 5904 listed here as one of the ore types.
Q. It clearly is cosmetic talc, correct? Johnson & Johnson talcum-powder products are made of cosmetic talc, true?
A. Yes.
Q. And there are no specific ore types listed here. It's talking generally about the types of applications, such as roofing, plastics, and then it says "cosmetics," correct?
A. Under the "Ore Destination" at the bottom it says "Ore Destination: Columbian Mill, Roofing, Plastics (TC 100)."
Q. Okay. And in terms of physical attributes, it says, "Generally good for all products including cosmetics," correct?
A. That's what it says.
Q. Let me ask you to turn to page Bates

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number 436961. I want to ask you some questions about the Hamm Mine.
And it's dated September 1992; do you see that?
A. Yes.
Q. And it's got "Ore Type," list A, B and C. And for associated minerals, it has actinolite and serpentine, correct?
A. That's what it says.
Q. And it says, "Physical Attributes" -- let me go back up. Sorry.
(Read as:) Mineralogy: Typical talc carbonate associated with serpentine. The rim of the foliated talc occurs mostly on the east but also high aspect ratio (flaky) talc is found the pit in the bottom next to the cinders, okay?
(Read as:) Physical Attributes: The ore deposit is on the north and -- excuse me -- is on the north end of a large serpentine mass. Included amphibolite and chlorite schists are removed by selected mining. The ore is very bright and flaky and makes a good source for both dry ground and floated products; did I read that correctly?
A. Yes.
Q. And then detrimental minerals, arsenic,

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actinolite and chlorite.
"In-Pit Contaminants: Serpentine, chlorite, mica (schist cinders)."
And in terms of destination, it says -- it talks about the Chester Mill. And then it says, "and float feed for West Windsor products and Johnson plant."
West Windsor products would be Johnson & Johnson talcum-powder products, true?
A. It might, depending on time.
Q. In the 1992 time frame, West Windsor was the location where Johnson's talcum-powder products were processed, true?
A. That's correct.
Q. You can put that aside. I'm going to show you what I've marked as Exhibit Number 14, Mr. Downey.
(Exhibit 14 was marked for identification.)
MS. O'DELL: It's JNJ 000245002. And that is Exhibit 14.
Q. (By Ms. O'Dell) Have you seen this document before, Mr. Downey?
A. This appears to be a Johnson & Johnson document. It's an inch and a half thick. I don't know if I've seen this or not.

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Q. And it relates to the Hammondsville Mine, correct?
A. That's what it says, yes.
Q. And it is dated 1970?
A. That's correct.
Q. And the subject is "Geological Audit, Windsor Minerals, File Number 124." And it says at the bottom, "The attached report completes our work on the nature and magnitude of our ore body in Vermont from which we manufacture Baby Powder talc," signed Bill Ashton, or W. Ashton, known as Bill Ashton.
Have you heard of Bill Ashton before?
A. I think I've seen his name.
Q. Did you ever have the opportunity to meet Mr. Ashton?
A. No, I don't believe so. Is he still alive?
Q. I believe he's deceased.
A. Okay.
Q. Now, in relation to this document, it was prepared for J&J Research Center, and it appears to be, as it indicated on the front, an audit of the mines in Vermont.
Let me ask you this: From -- beginning in

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1989 when Cyprus would have had ownership of the Vermont talc mines, did J&J audit the operations in Vermont?
MR. PROST: Object to form.
A. I believe so. I don't know how frequently, though.
Q. (By Ms. O'Dell) Do you know what the criteria J&J used to conduct those audits?
A. Not specifically, no.
Q. Do you know if there were any reports generated from Johnson & Johnson initiated audits of the operations there in Vermont?
A. Initiated by whom?
Q. Johnson & Johnson or somebody they hired to act on their behalf.
A. I'm aware of at least one audit-type report from the late 1990s that I've seen.
Q. And what's your understanding of that particular report?
A. It was about the level of microbials in the product.
Q. And what was the issue with the microbials?
A. There were -- there was a silo of material that had been quarantined. They were

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following the regular process. The material was quarantined -- it was sampled. A deposit sample was obtained for the silo, or silos, and while awaiting for the microbial analyses to come back, that material was quarantined. It was not shipped. And the microbial count came back in exceedance of the specification. So that instigated an audit by Johnson & Johnson.
Q. Turning back to Exhibit 14, Mr. Downey, you'll see -- if you turn to the table of contents on page Bates ending 4, it's about three pages into the document. Then it goes through various aspects of the audit. And you'll see from the table, starting tables at the bottom of the page, that there are petrographic classifications and analyses of samples taken from drill cores; do you see that? And it goes onto -- over onto the next page. And it lists the drill cores that are being sampled. And we're going to get to some of the results.
But, I mean, drill cores are undertaken for purposes of understanding the size and contours of an ore body, fair?
A. Generally speaking, drill cores are used to obtain geologic information that includes the extents or the limits of the ore body. That's what

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you're -- that's one thing you're trying to find.
Q. You're also trying to find out if there are accessory minerals in the deposit that you need to be concerned about in the mining process, fair?
A. You need to understand the overall geology of the deposit as it relates to what you're trying to do.
Q. That's right, because the ore -- as geologists, as I understand it, think of ore, that's the mineral that you're going to extract and sell for purposes of a profit, right? That's what you're selling to a customer, is the ore.
MR. PROST: Object to form.
Q. (By Ms. O'Dell) Fair?
A. It can be. You know, there are other processes, you know, downstream that occur, beneficiation and other things.
Q. Of course. And -- but just talking generally, you're looking to define the ore body when you're doing drilling, and particularly drilling cores, and then you're looking to identify any other geological information that would be relevant to your mining of that particular ore body, fair?
A. Generally, yes.

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Q. And so I'm going to ask you, just in summary fashion, explain for the jury what it means to drill for core. I mean, I can give you my sort of really rudimentary knowledge, which is you drill. The drill has essentially a cylinder. And that basically -- you pull out of the earth a rounded sort of sample of all the material. You know, so if you drill 200 feet down, you pull core that's 200 feet long, and it's a cylinder of a certain diameter, depending on the drill, and geologists look at those cores to determine what's in the earth at the point of that deposit; is that fair?
A. Close.
Q. For a nongeologist?
A. For a nongeologist, I mean --
Q. Yeah. It's fair, right? It's not as accurate as maybe others can do, but that's a fair summary, correct?
A. You're extracting intact rock, generally speaking, typically more in ten-foot sections, not 2700 feet at a time.
Q. Right.
A. But, yes.
Q. But a total drill hole often will end at

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200 feet, 160 feet. It's quite deep into the earth, generally speaking?
A. It depends on where you're targeting, but it can be several hundred feet.
Q. Right. And so they may be do ten feet at a time, but oft times, you're really looking to see what is present quite a distance into the earth, fair?
MR. PROST: Object to form.
A. You're using the drill and extracting the cores to gain information about the rock that you encounter.
Q. (By Ms. O'Dell) And cores are something that, for a particular deposit, is -- one, it's an expensive endeavor to drill for cores?
A. Generally, yes. As opposed to other drilling methods, it's expensive.
Q. Yes.
And the cores are something that are saved for historical reference for that particular mine --
MR. PROST: Object to form.
Q. (By Ms. O'Dell) -- in most instances?
A. I mean, you're talking generally about mines. Most core -- well, I can't say "most core."

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Core is often saved.
Q. Yes. And it's something that provides mineralogical information, you know, for the future. So you could go back to a core that was drilled in 1970 and look at it, reference it, and if that area's not been mined, you would have relevant information for an analysis in 2018, true?
MR. PROST: Object to form; outside the scope.
A. I don't know about particular relevance. To the extent it still existed, it might be useful.
Q. (By Ms. O'Dell) All right. In this instance, looking back at Exhibit Number 14, we're looking at a report that looks at cross-sections of cores that were drilled in the 1970s. And if you'll go to page 5010 -- excuse me, sir, it's 5010, which is very early in the document. That's the Bates number.
A. Oh, I was thinking 100. I'm sorry.
Q. Yeah. 5010 is the last four digits of the Bates. And this is defined in the scope of this particular study. It says it's included an examination and a detailed geologic mapping of all accessible parts of the Hammondsville Mine. All available drill core was examined and the zones

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were split. It says one half was sent to Golden. Excuse me. One half was sent to Golden for mineralogic and mineral assaying and the remainder was placed into core boxes at Windsor; do you see that?

A. So these -- it says "chemical assay," not "mineral."

Q. Sorry. I was reading ahead. Excuse me.

Okay. So this is a study of cores and the review that Johnson & Johnson initiated to look at cores to determine information about the Hammondsville Mine.

MS. ZOU: Objection to form. Sorry. Are you done? I didn't mean to interrupt.

MS. O'DELL: That's okay. Objection?

MS. ZOU: Object to form; outside the scope.

MS. O'DELL: Are you taking the position that the Hammondsville Mine is outside the scope of this deposition?

MS. ZOU: No. I'm taking the position that Mr. Downey is supposed to testify about the talc that Imerys sold to Johnson & Johnson, and this document's from Windsor Minerals.

MS. O'DELL: Okay. But you're not disputing that Imerys sold talc from the Hammondsville Mine?

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MS. ZOU: I am not disputing that.

MS. O'DELL: My objection to form is his interpretation of the document.

Q. (By Ms. O'Dell) If you'll turn to the Bates number ending 5020, it says, "Thirty-eight core samples were submitted for thin-section analysis. All but a few" --

A. Where at?

Q. At the bottom, sir.

A. Okay.

Q. Do you see that?

"All but a few," "...were from within the ore zone"; do you see that?

A. Yes.

Q. So that gives further information about the study that's being done on the Hammondsville Mine?

MR. PROST: Object to form.

Q. (By Ms. O'Dell) And for purposes of saving some time, let me have you turn over to another page that sort of shows the scope of this testing that Johnson & Johnson commissioned. And if you'll look on Bates number ending 5038 --

A. Three what?

Q. 5038.

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A. Eight?

Q. Eight. Eight. You'll see -- 5038 -- you'll see that it says, "In addition, almost forty samples of core material were submitted for thin-section analysis to determine various information about the host rock, the ore, and the origin of the deposit."

Before we go into the results of those tests, Mr. Downey, what is a thin section? What does that refer to in relation to analyzing a core sample?

MR. PROST: Object to form.

A. I think that Julie Pier -- that's a topic more on what she could discuss or describe better than I could.

Q. (By Ms. O'Dell) Based on your decades of experience in the mining industry and your education as a geologist, what's your understanding of what "thin-section analysis" means?

A. Generally speaking, a thin slice of rock is prepared on a slide that can be viewed under a microscope. That's my general understanding.

Q. And it's often reviewed under XRD, correct?

MR. PROST: Object to form.

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A. That's not my understanding.

Q. (By Ms. O'Dell) Okay. Turn to Bates number ending 5040, please. Do you see that?

A. Where?

Q. It's "X-ray Diffraction and Microscopic Data, Diamond Drill Hole 1-67-H"; do you see that?

A. Yes.

Q. And at the top, it shows the interval.

And then, to the right, it has 39 to 41; do you see that?

A. Yes.

Q. Most often that would mean feet, right, in a thin-section analysis of a core sample?

A. That's in -- the interval, there's "feet" in parentheses, so that indicates the units that you're measuring.

Q. That's right.

And so that would be results -- under 39.0 to 41.0 are the results of the samples taken at the 39-foot mark, between the 41-foot mark, true?

A. That's what it appears to me, yes.

Q. And if you'll look down in the second part, you'll see "Fibrous Talc." And under "Fibrous Talc," it appears it's 20 percent fibrous talc, and then going across to the lower section,

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10 percent fibrous talc, and then 10 percent fibrous talc; do you see that?
MS. ZOU: Objection; outside the scope.
A. That's what it says.
Q. (By Ms. O'Dell) If you turn to the next page, you'll see results from drill hole 6-67-H; do you see that?
A. Dash 8?
Q. H.
A. Okay. Sorry.
Q. H?
A. With my hearing, if you enunciate the ends of the words, that's my clue.
Q. Yeah. Sorry. I'm looking down at the document and not looking at you and it makes more difficult. And I apologize.
So we've got drill hole 6-67-H; do you see that?
A. Yes.
Q. And that drill hole that has been -- the core has been measured at various feet, 139 to 141.7, 149 to 153, and so on.
And if you look down below, you see it has 10 percent, 5 percent, 20 percent, 10 percent, and then for two sections, 5 percent fibrous talc; do

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you see that?
A. Yes.
Q. And fibrous talc is asbestiform talc, correct?
MR. PROST: Object to form.
A. Not to me, it's not.
Q. (By Ms. O'Dell) Is it your understanding, Mr. Downey, that that fibrous talc can have the same cancer-causing properties as types of asbestos?
MR. PROST: Object to form.
A. No.
Q. (By Ms. O'Dell) Okay. All right. Turn over to page 5050, test results for diamond drill hole 44-67-H. And they tested intervals between 299 feet and 309 feet. And tremolite-actinolite was .5 percent and .4 percent respectively, correct?
A. Yes.
Q. And that was material that was examined under x-ray diffraction and -- or x-ray diffraction, just in there?
MR. PROST: Object to form; outside the scope.
Q. (By Ms. O'Dell) True?

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A. I'm sorry.
Q. That material was examined under x-ray diffraction, true?
A. That's what it says.
Q. Okay. Turn to the next page. You'll see results from diamond drill hole 45-67-8. Interval between 903 and 905 feet was examined, and they found .4 percent tremolite, true?
MS. ZOU: Objection.
MR. PROST: Join.
THE WITNESS: What did you say?
MR. PROST: I joined -- I joined Shasha's objection.
A. That's what it says.
Q. (By Ms. O'Dell) And I could go on and walk you through the other tables, Mr. Downey, but do you have any reason to doubt the results reported in this report commissioned by Johnson & Johnson?
MR. PROST: Object to form.
MS. ZOU: Objection.
A. Miss Pier would be the one to discuss any interpretation of the results. I don't dispute that these records say what they say, as written.
Q. (By Ms. O'Dell) Okay. Has Imerys

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commissioned any examination of the Hammondsville Mine during the time period since 1989? And I'm referring to -- when I say "Imerys," I mean Cyprus, Rio Tinto, Luzenac or Imerys.
Are you aware of any geological survey or audit that those entities have commissioned for purposes of examining the Hammondsville Mine?
A. That would have been in that time frame that you're asking, beginning in 1989. That's when Cyprus purchased the Hammondsville Mine. And it only operated for a couple of years, so that only would have been Cyprus, but I don't know if Cyprus conducted a survey that you describe. It's possible. I don't know if I've seen record of it or not.
Q. It's possible, but you don't know?
A. I don't recall.
Q. Have you ever asked for information regarding the Hammondsville Mine?
A. Yes. As indicated in my notes from earlier, I had asked for information.
Q. But you didn't receive any?
A. I think I saw some information of a set of documents that were produced. I saw them sometime yesterday.

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Q. And was that -- what document are you referring to?
A. As I described them earlier today, it was several pages -- I don't know if it was all one collection or not -- of various, but as I recall, I think there was some information on Hammondsville there.
Q. Have you ever seen a specific examination of a specific audit report or examination of the Hammondsville Mine? I mean, you're talking about you've seen references. You said yesterday you saw documents that referenced Hammondsville. But I'm asking a more specific question. Not the document that just refers to it, but a specific analysis, memorandum, of the Hammondsville Mine.
A. I don't recall.
Q. Let me show you what I've marked as Exhibit 15 and ask you if you've ever seen this document.
(Exhibit 15 was marked for identification.)
A. (Document reviewed.)
Q. (By Ms. O'Dell) Did Imerys counsel provide this document to you in preparation for your deposition today?

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MR. PROST: Objection.
A. I haven't seen this document before.
Q. (By Ms. O'Dell) Let me show -- ask you to turn to page 2, and you'll see, Mr. Downey, it is a Report of the Geology Section, Windsor Minerals Inc. It's entitled "Geology and Ore Reserves of the Hammondsville Ore Body," by William Gregg, dated February the 20th, 1978.
And you've not seen this before?
A. I don't believe so, no. (Document reviewed.)
Q. Have you had a moment to take a look at it?
A. It's a lengthy report. The brief time I have looked through it wouldn't do justice of trying to figure out what it means.
Q. All right. Let me just ask you a couple of general questions about the report itself. Turn to page ending 976. So you'll see at the beginning under "Introduction," it says the report marks the completion of diamond-drilling program initiated in '76 to further define the Hammondsville ore body at depth below the presently worked fourth -- and that's 690 feet -- level; did I read that correctly?

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A. Yes.
Q. And that sentence underscores the fact that Hammondsville, unlike Argonaut and others, was an underground mine, true?
A. That's correct.
Q. And so this drilling was an effort to evaluate the ore body around the areas that had been tunnelled and were currently being mined?
A. I didn't catch the first part.
Q. That had been tunnelled, the underground tunnels and the areas that were currently being mined. This was an effort to further define the ore body in order to determine where they could continue their underground mine process, fair?
MR. PROST: Object to form; outside the scope.
A. Generally, yes.
Q. (By Ms. O'Dell) Okay. Let me ask you just a practical question.
On page Bates ending 991 of this document, it refers to the core boxes. And in the document it says that they're stored and gives you, basically, a description of where the particular drill cores are stored for the specific drill holes; do you see that?

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MR. PROST: Object.
A. I'm trying to familiarize myself with what's going on here.
Q. (By Ms. O'Dell) Looks like a diagram.
MR. PROST: Outside the scope.
A. We're on 91?
Q. (By Ms. O'Dell) Yeah. Mm-hmm.
A. Did you say "second diagram"?
Q. It's a diagram.
A. Okay.
MS. O'DELL: And the reason I don't think it's out of the scope is because we've covered cores, core logs, and this is cores.
Q. (By Ms. O'Dell) And I'm asking a specific question, Mr. Downey. In your visits to Argonaut, have you visited the location where core logs are stored at the Vermont mines?
MR. PROST: Outside the scope. And my objection is my understanding is that it was specifically made outside the scope in terms of retention or storage, so . . .
A. I haven't visited where the core boxes are stored.
Q. (By Ms. O'Dell) Okay. All right. Mr. Downey, I would take you through that, but I'm

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going to spare you for purposes of time.
We've talked about Hammondsville. And in light of the fact that Imerys or the predecessor companies had not performed an analysis, I have brought to the deposition today the J&J analyses of the Hammondsville Mine.
But it's your testimony you've never seen those before today?
A. I have not.
Q. All right. Let me show you what I'm going to mark as Exhibit Number 16.
(Exhibit 16 was marked for identification.)
Q. (By Ms. O'Dell) And I folded this because it was -- it was legal and it wouldn't fit in my box.
MS. O'DELL: So here you go.
Q. (By Ms. O'Dell) Have you seen these maps of the Hammondsville Mine before?
A. No, I have not.
Q. Have you seen other maps of the Hammondsville Mine, detailed maps similar to these?
MR. SILVER: Can you please put on the record the Bates numbers?
MS. O'DELL: It's Exhibit 16, JNJ 000261701.
Q. (By Ms. O'Dell) And so to go back where

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we were before I put the Bates number on the record, I asked you if you had seen any detailed geologic maps of the Hammondsville Mine prior to the set I put before you. And as I understand it, your answer's "no"?
A. I don't believe I've seen any geologic map -- or mine maps of Hammondsville.
Q. Are you familiar with the underground mining operation at Hammondsville?
A. It was closed before my first trip to Vermont.
Q. So you're not familiar with that?
A. No, not -- I don't have any personal information about it, personal knowledge.
Q. Do you have any knowledge that you have gained about the operation of the Hammondsville Mine during the course of preparing for this deposition?
A. No, just that I knew that it was an underground mine.
Q. Okay. You may put that aside, Mr. Downey. Thank you.
I'm going to transition now to the Hamm Mine.
A. Okay.

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Q. What period of time did the Hamm Mine supply talc, J&J talc?
A. It was first indicated as an approved source, I believe, in September of 1990.
Q. And when did Hamm cease to be a source of talc for Johnson & Johnson products?
A. Generally speaking, when Argonaut became the sole source. I think that was in '94 or '95.
Q. Is that -- do you have a specific recollection of that or are you just sort of guessing?
A. That's my recollection.
Q. Is it '94 or '95? Is that what you said?
A. It's '94 or '95. That's my recollection.
Q. Are you aware that, in 1992, a core drilling -- core drilling was performed at the Hamm Mine?
A. No.
Q. And just for the jury's sake, Hamm is an open-pit mine, correct?
A. Yes.
Q. And so open-pit mines involve drilling, inserting, you know, dynamite or some kind of

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explosive into a hole, setting off the explosive, removing the overburden and then, you know, mining the ore that's soft, fair?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) I mean, that's the general -- that's a general description of open-pit mining?
A. It can be. It depends on the type of mine, the geology and other things, other factors.
Q. But for Hamm, it was an open-pit mine that utilized blasting for purposes of the mining process, true?
A. It was an open-pit mine. Again, I -- it was closed before my first visit to Vermont. I hadn't seen the mine, so I don't have direct knowledge that they blasted, but blasting is a common method that is used in open-pit mining.
Q. And is it your understanding that that method was used at the Hamm Mine?
A. I don't have any personal knowledge of that.
Q. Were you provided any information? Did you seek to educate yourself about the manner in which mining was undertaken in the Hamm Mine?
A. I did. It may have been in some of the

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documents I saw sometime yesterday. There may have been something in that, but, again, that was a stack of documents that I reviewed. It may be in that information. I don't know.

Q. And as you're sitting here today, you don't have any --

A. I don't recall.

Q. You don't recall any information about the mining operations at the Hamm Mine, correct?

A. For Hamm specific, I don't have a recollection.

Q. I'm going to show you what I've marked as Exhibit Number 17.

(Exhibit 17 was marked for identification.)

Q. (By Ms. O'Dell) It's a core log for drill hole 921 -- 92-1 that was drilled on April the 25th, 1992. I'm going to hand you a series of documents, Mr. Downey.

Second exhibit, number 18, represent to you it's a core log from drill hole 92-2.

(Exhibit 18 was marked for identification.)

MS. O'DELL: For purposes of the record, Exhibit 18 is IMERYS 435996, and it's dated April 26, 1992.

THE WITNESS: April what?

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MS. O'DELL: Excuse me. Let me do that again. April 27, 1992.

And I'm going to give you the Bates number again. It's IMERYS 435992, and that's Exhibit 18.

I'm going to mark Exhibit 19, which is IMERYS 435996. And it is dated April 26, 1992.

(Exhibit 19 was marked for identification.)

MS. O'DELL: I'm also going to mark Exhibit Number 20, which is Imerys 436000, dated April 29th, 1992.

(Exhibit 20 was marked for identification.)

Q. (By Ms. O'Dell) Have you seen these documents before, Mr. Downey?

A. No.

Q. Were you aware that, prior to seeing these documents, that core logging had been done in the Hamm Mine in 1992?

A. No.

Q. I'll ask you to go back to Exhibit 17. And just for purposes of educating the jury, up at the top, it gives general information about the location of where the core has been drilled, correct?

A. Yes.

Q. And the location is given as a plot on

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essentially a grid, a mine grid, correct?

A. Yes.

Q. And it's north 9421.7 and then east, I think it's 10093.5.

And so for someone reading this, that gives a very specific location as to where that core was taken?

A. That references where the collar of the drill hole was located.

Q. So the drill was located there. That's where the collar was located, but the drill -- you could drill either straight down or you can drill at an angle.

And so just depends on what they were actually doing, correct?

A. That's correct.

Q. All right. So in this instance, the inclination of where the drill was directed is bearing north 50W, and then the inclination is minus 70 degrees, correct?

A. That's what it says.

Q. And that's not unusual that you don't necessarily drill straight down, for those that are not familiar.

You drill -- you can drill at an angle, and

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often you do drill at an angle to try to better understand the ore body?

A. Yes.

Q. And this particular hole was drilled to 250 feet?

A. Yes.

Q. And then you come down and it will -- it provides information regarding the ore type. And it gives a description of the core that's being pulled. And then if you look to the very left, that number 5, number 10, number 15, number 20, that's the feet?

A. In the very left column?

Q. Yeah.

A. Yes.

Q. So as the cores are drilled and they're pulled out of the shaft where the drill -- I don't know if that's the correct term, but the shaft where they pull the material from the hole, then a geologist will look at that material and describe it, and that's what becomes a core log, correct?

A. Yes.

Q. And so if you look across after "Core Description," you'll see the percentage of talc that's contained in that particular section,

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percentage of amphiboles; do you see that?
A. Yes.
Q. Percentage of "sulf," what does that stand for?
A. I believe sulfide.
Q. Okay. And then you have percentage of opaque; do you see that?
A. Yes.
Q. Okay. So -- and then you have percentage of recovery.
And what does percentage of recovery refer to?
A. Sometimes in a fractured zone, you don't extract all of the material, and so the recovery is the material that you obtained.
Q. Okay. So that gives us a general understanding of core logs.
Let me show you what I'm going to mark as Exhibit Number 21.
(Exhibit 21 was marked for identification.)
MS. O'DELL: And for the record, that's IMERYS 238270.
Q. (By Ms. O'Dell) Have you seen this document before?
A. No.

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Q. And this is a report from R.J. Kellie and S.B. Carpenter, dated May 21st, 1992. And the subject is "Hamm Core Drilling"; do you see that?
A. Yes.
Q. And does this appear to be -- and take a look at it -- a report that describes the findings from the drill holes that we just looked at the core logs?
A. (Document reviewed.) What's your question again? I'm sorry.
Q. Would you agree with me -- make it a little easier -- that this report is a report from R.J. Kellie and S.B. Carpenter regarding the four core drills that they conducted in April of 1992, hole 92-1, hole 92-2, hole 92-3 and hole 92-4?
MR. PROST: Object to form.
A. This memo describes -- or is a report that includes information on those four holes, yes.
Q. (By Ms. O'Dell) All right. And you'll see a summary at the top. He's talking about "With the information gained from the recently completed USB core drilling," and that's referring to U.S. Borax, correct?
(As read:) USB core drilling, some 1.8 million tons of combined mineable talc ores with a

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waste-to-ore ratio of 0.52:1 are calculated within the confines of the planned open pit at Hamm in Vermont; did I read that correctly?
A. You missed a few words, but that's generally what it says.
Q. Okay. Look down on paragraph two. (As read:) Fibrous amphiboles (actinolite) were observed only within the chloritized mafic dikes, extending, in places, a couple of inches into the contact talc ore; did I read that correctly?
A. Yes.
Q. And it says, "An XRD amphibole scan, made on all sampled core intervals, yielded negative results." And I'll talk to you about that some more, okay?
But in terms of these chloritized mafic dikes which contained actinolite, based on this sentence there, those dikes were located a couple of inches into the contacting talc ore, true?
MR. PROST: Object to form.
A. That's what it says.
Q. (By Ms. O'Dell) Okay. If you'll look on page 2, bottom, it says, "In spite of production demands and its overall strategic value" -- and that's referring to the Hamm Mine, correct?

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A. I'm trying to find what's --
Q. Sorry. Last paragraph. "In spite of the production demands and its overall strategic value," and we're talking about -- "its strategic value" refers to the Hamm Mine, correct?
A. I think that's what it says at the continuation of that sentence.
Q. "...the ore reserves of the Hamm Mine were poorly understood. Previous drilling had not delineated the talc body with respect to country rocks nor was ore continuity with depth clearly established. In order to adequately measure the remaining ore reserves, additional drill information was needed, particularly at depth within the limits of the proposed pit. It was also necessary to interpret, with new drilling, existing sources of information. Many of the available drill logs simply referred to 'type 30' or 'type 20' ore."
Do you know what "type 30" ore is?
A. No.
Q. Do you know what "type 20" ore is?
A. No.
Q. "...some simply stated 'talc' or 'non-ore.' Believe it or not, some holes were not

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even logged or analyzed. Due diligence drilling was clearly necessary to complete the evaluation of the important Hamm reserves"; did I read that correctly?

A. Yes.

Q. If you'll turn the page, then it describes the four in-pit sites were collected, the ones we just referenced, and we marked the core logs that were generated from that drilling. And it says 92.1 was to test the extent of type 30 ore. And then it says talc/carbonate, 40 to 50 percent talc, exposed to the pit bottom, delineate serpentine -- excuse me, delineate serpentinite mass.

Mr. Downey, was talc ore composed of talc/carbonate, 40 to 55 percent, ore that would have been appropriate for Johnson & Johnson's talcum-powder products?

MR. PROST: Object to form.

A. I can't tell that from this document.

Q. (By Ms. O'Dell) Moving on to hole 92-1 [sic], "To add confidence to a large area of projected reserves on section 4 plus 00 and delineate the amphibolite exposed in the southern pit wall"; did I read that correctly?

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A. Yes.

Q. And amphibolite is another variation of amphibole, correct?

A. Generally it's a -- I think a broad term that collectively is amphibole minerals.

MR. SILVER: Leigh, just to correct the record, you had said, "moving on to hole 92-1," but you read from 92-2.

MS. O'DELL: Two. I didn't -- sorry. I didn't mean to.

MR. SILVER: It's fine. It's late in the day.

MR. PROST: I was going to tell her.

MS. O'DELL: Well, if I'm looking at something and I'm saying something else, I'll often get off track, so thank you for that. I was reading from 92-2.

Q. (By Ms. O'Dell) The bottom line is, the core logs that we just marked as Exhibit -- I believe it was 17320, are being analyzed in this memo, and the specific purposes of those holes are being described in this memo, correct?

A. Yes.

Q. Okay. Let me ask you a few more questions.

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If you look down to the "Drilling" section, it mentions a contract mining company by the name of MacKenzie Construction.

Who is MacKenzie Construction?

A. I've seen MacKenzie Construction referenced as the contract miner at Hamm.

Q. And what -- in terms of contract mining, what was general scope of the work of MacKenzie Construction at the Hamm Mine?

A. Other than that they did the contract mining, I'm not sure.

Q. What is meant by "contract mining"?

A. Generally speaking, a mine operator can either do the mining themselves or they can farm it out to a third party known as a mining contractor.

Q. When you say "mining," what are you referring to? Are you talking about the drilling? Are you referring to blasting? Are you referring to removing overburden? What are you referring to when you're talking about a contract miner?

A. Well, generally speaking, a mining contractor might have the entire scope, but depending on the type of mine and the type of contracts, a mining contractor might -- there might be more than one contractor involved, maybe one for

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drilling, another for doing the mining. I don't know.

Q. What was -- and you're not aware of what MacKenzie Construction Company's role was at the Hamm Mine?

A. Other than the reference that I saw that they were the mining contractor, that's pretty much all I know.

Q. And you don't have an understanding of the scope of the work that they performed at the Hamm Mine, true?

A. I don't know the entire scope, no.

Q. Okay. Let's turn to the last -- excuse me, not the last page, but page 4 of the document ending Bates 273. It's referring to the logging and sampling.

So the drill cores were logged at the site of the drilling, correct? It says, "Drill cores were logged on-site."

A. Yes.

Q. And if you'll move down a paragraph, it says -- excuse me, down the page to the paragraph beginning, "Drilled internal waste rock"; do you see that?

A. Yes.

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Q. "Drilled internal waste rock was comprised of serpentinite and chloritized, mafic dike. Hole 92-4 penetrated garnet schist foot wall. Fibrous actinolite was seen in chloritic dikes and occasionally extended a few inches into the talc ore at contacts. No other asbestos-form minerals were noted in the drill cores"; did I read that correctly?

A. Yes.

Q. So Mr. Kellie and Mr. Carpenter did note fibrous actinolite in the chloritic dikes that occasionally went into the talc ore, true?

A. Show me again where you're reading? I'm sorry. I lost you.

Q. Same paragraph. And really asking you the question: Actinolite, fibrous actinolite, was seen in chloritic dikes that occasionally extended into the talc ore, true?

A. This says that "occasionally extended a few inches into the talc ore at contacts."

Q. It went on to say, "Analytical sample intervals were selected primarily on the basis of ore type."

So in other words, the samples that were taken for purposes of analysis were selected based

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on ore type, correct?

A. Yes.

Q. "Whenever possible, sample length was 15 feet."

"Sample length" means the distance between -- on a particular core, between one sample and the other. So if you had a 250-foot hole, this sentence is saying the sample length was -- they tried to make it 15 feet, correct?

A. They said, "Whenever possible, sample length was 15 feet."

Q. Okay. (As read:) The minimum sample length was 9 feet unless the interval bounded -- excuse me -- unless the interval bounded internal waste rock.

MR. PROST: Ten feet.

A. I don't know if your document says 9 or 10. This one says 10.

Q. (By Ms. O'Dell) Okay. I really am getting tired. I need some more chocolate. I did see "10." Okay. Let me read that again.

"The minimum sample length was 10 feet unless the interval bounded internal waste rock"; did I read that correctly?

A. Yes.

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Q. All right. Then it says, "Talc ore observed to contain fibrous amphibole was not included in a sample interval"; did I read that correctly?

A. Yes.

Q. Mr. Downey, this is talking about talc ore. And where talc ore was observed by these geologists to contain fibrous amphibole, it was not sampled, correct?

MR. PROST: Object to form.

A. It says it was not included in the sample interval.

Q. (By Ms. O'Dell) Correct. My statement was correct, wasn't it?

A. You can have it read back, but it says what it says.

Q. It says that samples of -- were not taken where fibrous amphiboles were seen or observed in talc ore, true?

A. It says, "Talc ore observed to contain fibrous amphibole was not included in a sample interval."

Q. Let me ask you to look -- to turn to, excuse me, the last page of the document, page 6, Bates number ending 275. I ask you to look at the

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last paragraph.

A. There's two more pages. I don't know if that's the last page of the document.

Q. Yeah. Oh, my apologies. 1275 is the right page. Okay? Take a look at the last paragraph, please. It says, "XRD scanning did not reveal the presence of amphibole in the drill core. This is consistent with the selected sample intervals"; did I read that correctly?

A. Yes.

Q. Isn't it true, Mr. Downey, that if samples were not taken of fibrous amphiboles in talc ore, then it's not surprising that the XRD scanning would be negative?

MR. PROST: Object to form.

Q. (By Ms. O'Dell) True?

A. This is the first time I've seen this document. I think that there's -- I'm not familiar with their methodology, but because they intentionally didn't sample that interval that way, this conclusion is accurate.

Q. If you don't sample it, it's not surprising if you don't find it, true?

A. I think, based on selective mining, which was what Cyprus indicated that needed to be

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done at Hamm in order to be able to mine it --
Q. And my question -- excuse me, sir -- is a little bit more simple.
I'm saying, if you don't sample something, it's not surprised -- it's not surprising that you don't find it in the test results, correct?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) So if they weren't sampling fibrous amphiboles, the fact that the XRD test for amphiboles was negative is not surprising --
MR. PROST: Object to form.
Q. (By Ms. O'Dell) -- true?
A. It's my understanding that their sampling method matched their -- what they expected from selective mining.
Q. So the answer to my question is "yes"?
A. I forgot the way you asked your question.
Q. If they weren't sampling fibrous amphiboles, the fact that XRD tests for amphiboles was negative is not surprising.
MR. PROST: Object to form.
Q. (By Ms. O'Dell) That's correct?
A. Their sampling methodology was for their

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mining method. They clearly have other indications that the amphibole mineral is present.
Q. Where does it say that their -- when we went over the sampling protocol and it talked about the intervals at which analytical samples were taken, it does not mention selective mining, does it, Mr. Downey?
A. No. The documents that I'm aware of on the due diligence for Hamm, Cyprus clearly indicated that selective mining was going to be necessary, and that's what they employed.
Q. I'm not disputing with you that selective mining was employed at Hamm, but in terms of this testing, selective mining is not a part of the analysis that's contained in the memo that we just looked at, correct?
A. What do you mean it's not?
Q. In terms of what they were sampling and testing, selective mining was not a part of that analysis?
A. It's my understanding that their sampling method was to correlate with their selective-mining method.
Q. How did you get that understanding? You didn't even know that those -- that drilling had

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taken place until I showed you the core logs.
A. From the due-diligence reports from -- that Cyprus had done, it clearly states that they needed to employ selective mining.
Q. Okay. And is that -- this memo that we've just gone over talks in terms of sampling in terms of feet. They sampled -- they tried to sample every 15 feet. If they couldn't do that, a minimum of 10 feet, they took a sample. That's the extent of their protocol for sampling in that particular analysis, true?
A. The selection of the sample interval is also correlated to the bench height of how you are mining the deposit.
Q. Bench height was not mentioned in the memorandum analyzing the core drilling that was done at Hamm in 1992, true?
A. I haven't read the entire document.
Q. In the expansive portions that we've gone through, bench mining was not mentioned, true?
A. I don't recall seeing that.
Q. And moreover, selective mining was also not a part of -- selective mining was also not a part of the analysis as outlined in the memorandum we've marked as Exhibit 21?

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MR. PROST: Object to form.
A. In terms of what?
Q. (By Ms. O'Dell) Selective mining is not mentioned, correct?
A. I didn't see it, no.
MR. PROST: You're getting close to the end of that document. I think we're hitting the home stretch, kind of. Do you want to take a final five-minute break?
MS. O'DELL: Yeah, that's fine.
MR. PROST: That may be a good idea.
VIDEOGRAPHER: All right. Off the record at 5:14.
(Recess taken.)
VIDEOGRAPHER: We're back on the record at 5:32.
Q. (By Ms. O'Dell) We were talking before the break, Mr. Downey, about core logs and specifically core drilling that was done at Hamm in 1992. And let's just take a step back.
The purpose of doing core drilling is to obtain information that can be used to create a model of the particular ore body or potentially some things that surround the ore body in order to provide information on how to mine that particular

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deposit, true?
A. I mean, that's -- that's something you can use drilling for, but, yeah, you're trying to find out information that's relevant to what you're going to mine and how you're going to mine.
Q. Yes. And one of the things that Imerys does, I understand, and as well as all modern mining companies, is they take data from core logs and they actually do create a computer model of the particular deposit?
A. Yes.
Q. And Imerys routinely does that as part of their business practice, true?
A. Yes.
Q. And so when trying to create a model or an understanding of a particular deposit, you know, that model is only as good as the information that's provided to create it, true?
A. Well, it also needs to be relevant for how you plan to mine. There's a lot of information, and you're digesting information so that you can make your mine plans.
Q. But the mine plan and selective mining is based on -- or should be based on an accurate understanding of the material and minerals in a

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deposit, fair?
A. Yes.
Q. If you don't have good data about what's in the deposit, you cannot effectively selectively mine it, true?
A. The data certainly helps, but also, part of selective mining is, you know, visually examining the material that you are mining.
Q. And for purposes of a mine model being generated following the drilling of cores, that model is only going to be as good as the information provided by the samples taken from that core, correct?
A. There's lots of ways that information can be incorporated into a mine model that also includes development drilling and geologic mapping as the mine advances. So the data is being updated. It's not static.
Q. But the model itself is only as good as the accuracy of the data that's provided to create the model.
MR. PROST: Object to form.
Q. (By Ms. O'Dell) True?
A. Having accurate data certainly helps the accuracy of the model, but the model, in and of

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itself, is the model. And it's the practice of using all of the knowledge, including what's in the model, but also what the geologists know about the deposit and what they continue to learn about the deposit as they examine the mining phases as the mine advances. Are you inferring that --
Q. I got to ask you a question, Mr. Downey.
All right. Let me ask you one more thing about the drill locations in relation to these four drill holes that were drilled at the Hamm Mine in '92. And if you'll look at 92-1, which was Exhibit 17, and the particular location, Mr. Downey, you'll see the location was north 9421.7 and then east 10093.5; do you see that?
A. Yes.
Q. And then the second drill hole, 92-2, was drilled at location north 9258.9 and then east 999 -- three 9s -- 9990.3; do you see that?
A. Yes.
Q. And that -- those drill holes, by my estimation, are in the neighborhood of 180 feet apart, correct?
A. It's late in the day. I'm not going to do the geometry to figure out how far apart they are.

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Q. They're more than 10 feet apart, true?
A. Yes.
Q. They are more than 50 feet apart, true?
A. Yes.
Q. In fact, they're more than 100 feet apart.
A. Of the collar locations, yes.
Q. And if you'll look at drill hole 3, which we marked as Exhibit 18, and drill hole 4, Exhibit 20, the location of the collar for those drill holes is the same place, correct?
A. Yes. Looks like they were drilled at different bearings.
Q. Let me show you what I'm marking as Exhibit Number 22.
(Exhibit 22 was marked for identification.)
MS. O'DELL: It's Bates number ending -- or excuse me, Bates number IMERYS 427291.
Q. (By Ms. O'Dell) Have you seen this document before?
A. I don't know.
Q. If you'll turn to page 2 of the document, you'll see that this is a master plan for Northeastern mines, and it includes Hamm, Argonaut, Rainbow; do you see that?

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A. Yes.
Q. And if you'll look at the top, then, this is the fax from Luzenac Tech Center, August 19th, 1993; do you see that?
A. Yes.
Q. And if you'll look on Bates number ending 95, you'll see an analysis of the Hamm Mine.
A. Did you say 95?
Q. Yeah. 95. Do you see that?
A. I see Hamm listed, yes.
Q. And it says (as read:) This mining locality provides cosmetic ore feed to both the Johnson Mill and West Windsor.
And, of course, West Windsor, we agree, covers Johnson & Johnson talc?
A. Grade 25 was manufactured at the West Windsor Mill. That was the Johnson & Johnson product.
Q. Correct. And then it says "Contaminants"; do you see that?
A. Yes.
Q. "Actinolite is common with chlorite cinders and schist contacts"; do you that?
A. Yes.
Q. Let me ask you to look at the bottom of

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the page. It's referring to the Ludlow District, and then below that you see "Argonaut Mine."
A. Before we leave Hamm on contaminants, it says, "All contaminants can be avoided by selective mining."
Q. Okay. All right. I'll highlight that. We'll see about that.
"Ludlow," "Argonaut Mine," do you see that at the bottom of the page?
A. Yes.
Q. It says (as read:) This locality has recently been explored by nine core drill holes for footage of 3,712.
We were provided data on four drill core holes.
Do you have any information about the other five drill core holes that were done at the Argonaut Mine? Strike that. Never mind.
A. I'm confused.
Q. Never mind. I'll withdraw that.
Okay. Turn to the next page. All right. Do you see that? "Contaminants. Selective mining will be required at the Argonaut Mine to avoid high arsenic zones plus occasional zones of actinolite with chlorite cinders and serpentinite. Much of

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the drilling remains to be analyzed to provide a better profile of this resource"; did I read that correctly?
A. Yes.
Q. Would it be fair to say that both the Hamm Mine and the Argonaut Mine have deposits that are irregular? So you have certain zones of talc and then you'll move into zones of schist or some other material?
MR. PROST: Object to form.
A. I'm not really sure what you mean.
Q. (By Ms. O'Dell) I'm asking if the deposit of talc is a uniform body or if it's irregular and that there are other minerals and materials that flow in and through the talc deposit.
A. Well, "irregular" is a vague term, so I'm not sure how you mean it, as well as "other minerals that flow" through the deposit. That seems equally vague. I'm not sure what you mean.
Q. Have you ever read in a document or heard anyone discuss those ore deposits and refer to them as "irregular"?
A. I don't recall at this time.
Q. You've spent time this afternoon talking

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about selective mining in the context of the Hamm Mine. We're going to go into Argonaut in just a moment, but in the context of the Hamm Mine, what is your understanding of how selective mining was conducted?
A. I can give you an example.
Q. I don't want an example. I'm talking about specifically -- just -- I don't want to cut you off, but I'm running out of time, and I want to be clear.
You've represented that the Hamm Mine was selectively mined.
A. Yes.
Q. And you have testified to that under oath on behalf of the company.
And what I want to know from you is the facts you're relying on to -- well, let me back up and say, I want you to describe the specific way that selective mining was undertaken in the Hamm Mine.
MR. PROST: Objection to form.
A. The mafic material is dark-colored. The talc carbonate is a light-gray material. They're readily distinguishable when you're looking at them. The mine geologists can identify them. The

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driller can recognize the difference with the material that's coming out of the hole. There are lots of visual clues that tell you when you are in or near those zones. And you can employ selective mining based on those visual clues quite successfully at Hamm and similarly at Argonaut.

Q. (By Ms. O'Dell) And so what -- let me just step back and say, define "selective mining." Let's just step back. Define "selective mining."

A. Define it?

Q. Yes.

A. Generally speaking, selective mining is a method in which materials that you do not want to include in the ore are removed on a selective basis using distinguishable criteria when you are mining.

Q. What criteria do you use to distinguish those material you don't want?

A. Well, I told you about the Hamm and Argonaut. One of those is the color difference. It's a drastic color difference between those mafic areas and the talc. There's a color difference.

In addition to making the separation at that point, there's also an exclusion zone adjacent to that mafic of the talc carbonate that is also sacrificed and rejected along with the other

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material. So you have a buffer zone when you are mining near those areas.

Q. So selective mining is a visual process of --

A. There are usual.

Q. -- of looking at the rock and choosing, you're going to take some versus not other rocks, fair?

A. Visual is a component of it, but it's also the understanding of the overall geology of the deposit as well.

Q. And other than -- it's visual, in part. You mentioned color.

What other criteria are used in selective mining?

A. Well, the geologist, when examining the face, can look at the mineralogy as well. But one of the first clues is to look at the color of the zone, indicating that that's a likely place to -- or that's where the mafics are.

Q. And anything besides color?

A. Well, there's color. There's rock type. There's mineralogical aspects. I'm giving --

Q. What mineralogical aspect are you talking about?

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A. The minerals that you see.

Q. I mean, you know -- I mean, is the understanding of the mineralogy based on what is seen in the pit when you're doing selective mining?

A. That's part of it, but it's the understanding of the geology and how the deposit was formed and its relation to the other rock types. So there's a number of factors that -- I probably can't list all of them, sitting here today.

Q. Is it also based on the data contained in the core logs?

A. That's part of the information as well.

Q. And who actually does the selective mining?

A. In the critical zones where that's necessary, typically, the geologist is with the shovel operator if it's -- if they're mining it with a front shovel.

Q. And so it's equipment operators in the pit. We're talking about heavy equipment, front-end loaders --

A. They are the ones that are skilled in how to --

Q. Excuse me. I'm not -- front-end loaders

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in the pit that are actually removing the rocks from the pit in order to -- for it to be trucked to West Windsor or some other location, correct?

A. The heavy-equipment operators are the one skilled in actually operating a piece of heavy mobile equipment to do that extraction.

Q. And so on a daily basis, it's the equipment operator, primarily, who's making the selection as to what rocks are removed from the pit versus what rocks are not removed from the pit, correct? I mean, the geologist is not there all day, every day, saying, "Take this rock. Leave this one." You're not saying that, are you? Because that would --

A. No, I'm not.

Q. That wouldn't be true.

A. I'm not saying that, but in the critical areas where the selective mining is most critical, the geologist is involved in directing the activity.

Q. And how -- how, as a practical matter, how is -- how does the geologist mark which rocks are to be removed and which rocks are not to be removed?

A. I think it depends on the circumstances

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of how the rocks are exposed in the pit, its orientation and things like that.
Q. What's Imerys' policy in terms of marking out exclusion zones in a pit?
A. What do you mean "exclusion zones"?
Q. You used that term. You said there are exclusion zones beyond which material -- from which material shouldn't be taken for purposes of mining it. In other words, that material is not -- that's "wasted," I think was the word you used.
What policy -- what's Imerys' policy for marking exclusion zones in a pit?
A. As you mine, you are continuing to expose a fresh muck face. So the way that it is done is relative to a bucket width. Tell the operator to stand off a certain number of bucket widths away from the zone that's being rejected before mining the rest of the material as ore.
Q. And --
A. And these are the -- I'm not -- when I say a "shovel," I don't mean a hand shovel. This is heavy mobile equipment with a bucket that's maybe eight feet wide.
Q. How many cubic feet is that?
A. Pardon?

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Q. How many cubic feet would be in a bucket eight feet wide?
A. I can't recall, off the top of my head, how many cubic feet.
Q. And so it would be incumbent upon the equipment operator to stay one or two buckets, whatever the geologist has suggested, from a particular area when that equipment operator is removing ore from a pit, correct?
A. It would be?
Q. Incumbent.
A. Incumbent? Yes.
Q. What training does Imerys provide to equipment operators regarding selective mining?
A. They're trained --
Q. If any.
A. Sorry?
Q. If any.
A. They're trained to recognize different features. They're the ones doing it day after day, and they get to know the deposit. They talk with the geologists. You know, they describe what they're seeing. The geologist describes what he's seeing. It's a continual process. And we also try to use the -- a trained operator that's done it

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for, you know, ten years or more.
Q. Is there a specific program for training equipment operators that Imerys requires as a part of their, just, policy and procedure for ensuring that their employees are trained?
A. I don't recall.
Q. Is there a formal training program, in other words?
A. A formal training? I know that they are trained. I don't know to what extent there's documentation to describe the formal training.
Q. In terms of the machinery that's actually used in a pit to select ore, you know, for shipment to a mill, is that typically a front-end loader?
A. Typically it's a shovel.
Q. And when you say "a shovel," you're talking about a backhoe, is what some people call it?
A. A backhoe that is either configured for underhand or overhand. It depends on the nature of the deposit.
Q. At the Hamm Mine, do you know what type of equipment was used to remove ore from the pit?
A. I don't recall.

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Q. Have you ever known that information?
A. I might have seen it. I just can't remember.
Q. Within the pit itself -- any pit, not just Hamm, but any pit -- it'd be fair to say it's a very dusty environment. You've got blasts going off. You're moving rocks and other dirt. It's a very -- it's not a clean environment, in other words. It's a dusty environment.
MR. PROST: Object to form.
A. It can be dusty at some times.
Q. (By Ms. O'Dell) And it can also be, you know, a difficult place when it's dusty to identify material within the pit, fair?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) That's why you use XRD and other types of analysis to identify certain minerals?
MR. PROST: Objection.
A. No, I don't agree with that.
Q. (By Ms. O'Dell) Visual inspection has significant limitations; would you agree with that?
A. There are limitations to it.
Q. And those limitations grow when the pit is dusty, when conditions would limit your ability

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to identify certain rocks and what they are, true? I mean, that just makes -- that's common sense.
A. I think you're -- you don't -- I don't think you're describing -- or have in mind actual conditions in the pit.
Q. And so just -- it's your -- I mean, when you say you don't think I have in mind actual conditions, you think I'm misinformed to think that an open-pit mine would be dusty when it's -- when you haven't had rain recently? I mean, am I confused on that?
A. You're characterizing the dust to such an extent that it would obscure your ability to identify what you're mining. And that I don't think is correct.
Q. Not in whole, but it certainly would obscure, to some degree, your ability to identify certain rock with precision, correct?
A. Well --
Q. We can agree on that?
A. -- when you're mining, the dust is -- would be -- when the material is dropped from the shovel into the truck, there's a brief period of dust that's emitted when the material is falling, but that's not where the actual digging is

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occurring.
Q. Well, there's dust when blasts go off, correct?
A. There can be, yeah.
Q. Typically, quite a lot?
A. There's some.
Q. And so in terms of an operator, a shovel operator's ability to identify a particular rock, it's going to be based on, one, the conditions in the pit, whether it's dusty, not dusty, true? It's going -- true?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) True?
A. When the operator is digging the rock, you continue to expose fresh faces as you're digging it.
Q. And if that ore body is irregular, in other words, it's not uniform, then different materials, not just talc, but other things like schist, serpentinite, can be scooped up into that bucket along with talc, correct?
A. Say again? If it's --
Q. I'll repeat it.
And in a mine where the ore body is irregular, in other words, it's not uniform, then

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different materials, not just talc, but other things like schist and cinder can be scooped up into the bucket when ore is being removed from the mine, correct?
MR. PROST: Object to form.
A. No, I wouldn't agree, because the way that it's mined, the direction that you're mining is all factored in.
Q. (By Ms. O'Dell) So that's impossible?
MR. PROST: Object to form.
A. I'm saying that the practices employed with mining, selective mining, it takes into consideration the geometry of what's being mined at that time to account for potential irregularity. And as I mentioned earlier, we have the offset zone where we sacrifice a great deal of talc just to make sure that we are not incorporating accidentally this other material that you describe.
Q. (By Ms. O'Dell) And the accuracy -- or the carefulness, I should say, of what's being scooped up into the bucket for purposes of -- for putting it into the truck to send it to West Windsor, if you're talking about Hamm, is dependent on that shovel operator, true? True?
I mean, the shovel operator is the one that

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is scooping up that ore and putting it in the truck, so that what goes into that bucket is dependent on the judgment that that individual makes when they were removing the ore from the pit, true?
MR. PROST: Object to form.
A. It depends on the informed judgment of the shovel operator and any direction from the geologist about how that particular section should be mined.
Q. (By Ms. O'Dell) Some operators are not geologists, correct?
MR. PROST: Object to form.
A. They're not geologists, but they have a great deal of experience with the geology of the mine that they are digging in. They do it day after day.
(Exhibit 23 was marked for identification.)
Q. (By Ms. O'Dell) Let me show you what I've marked as Exhibit 23. It's IMERYS 427423.
Have you seen that document before?
A. (Document reviewed.) No.
Q. Let me ask you one more follow-up question to our discussion of the shovel operators.
Is there any minimum training required prior

to a person being allowed to operate a shovel in an Imerys talc mine?
A. Is there?
Q. Any minimum training required prior to a person being allowed to operate a shovel in an Imerys talc mine.
A. I believe for digging for ore, yes.
Q. What is that training?
A. I don't recall.
Q. Have you ever been to that training?
A. No. I'm not a shovel operator.
Q. Have you ever, just as a supervisor, when you're -- have you ever attended that training?
A. I've seen some of the training that's occurred at Yellowstone, and it's with a geologist interacting with the shovel operator.
Q. Do you have any personal knowledge of training that was conducted at the Vermont mines from 1989 to 2002 of their shovel operators?
A. No.
Q. Let me ask you to turn to page 23 of -- excuse me, to Exhibit 23, page 2. And this is a memo dated August 6, 1998. And it relates to the 1998 core drilling at Argonaut; do you see that?

A. Yes.
Q. And according to this document -- look at paragraph two. The Argonaut Mine has been core drilled, it says, in 1972, 1973, '78, '98 -- excuse me, '89, '92 and '98; did I read that correctly?
A. Yes.
Q. So there are six occasions, six years, during which core drilling was done at the Argonaut Mine?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) So core drilling has been done in Argonaut in '72, '73, '78, 1989, 1992 and 1998?
MR. PROST: Object to form.
Q. (By Ms. O'Dell) Have you --
A. As of this memo, those were the years.
Q. That's fair. As of this memo, those were the years core drilling had been done.
Have you reviewed the core logs for the core drilling that was done during these six occasions?
A. Not all of them. I've spot-checked a few of them.
Q. Which year?
A. Specifically I remember 1998. I don't recall which of the other years I looked at.

MR. PROST: Leigh, just so you know, about a minute and a half ago, the videographer gave a five-minute warning, so . . .
MS. O'DELL: Oh, thank you. I didn't see that.
Q. (By Ms. O'Dell) Let me ask you, if you have seen any core logs, whether you reviewed them or not for drill -- core drills that occurred in 1978.
A. 1978?
Q. Yes.
A. I might have. I just don't recall.
MS. O'DELL: How about I save my three minutes for tomorrow?
MR. PROST: I think it's only one minute and a half now.
MS. O'DELL: Okay. Whatever it is.
MR. SILVER: We're going to do whatever Joel says it is.
MS. O'DELL: It's good breaking point.
VIDEOGRAPHER: All right. Off the record at 6:15.
(Whereupon, the deposition was concluded at 6:15 p.m. on August 7, 2018.)

I, PATRICK DOWNEY, do hereby certify that I have read the foregoing transcript and that the same and accompanying amendment sheets, if any, constitute a true and complete record of my testimony.

_____
PATRICK DOWNEY

( ) No Amendments
( ) Amendments Attached
Subscribed and sworn to before me this _____ day of _____, 2018.

Notary Public: _____
Address: _____
_____
My commission expires: _____
Seal:

MLG

REPORTER'S CERTIFICATE
STATE OF COLORADO) ss.
COUNTY OF DENVER)

I, MELANIE L. GIAMARCO, do hereby certify that I am a Registered Professional Reporter and Notary Public within the State of Colorado; that previous to the commencement of the examination, the deponent was duly sworn by me.

I further certify that this deposition was taken in machine shorthand by me at the time and place herein set forth, that it was thereafter reduced to typewritten form, and that the foregoing constitutes a true and correct transcript of the proceedings had.

I further certify that I am not employed by, related to, nor of counsel for any of the parties herein, nor otherwise interested in the result of the within litigation.

In witness whereof, I have affixed my signature this 21st day of August, 2018.

Melanie L. Giamarco
Registered Professional Reporter
Registered Merit Reporter
Certified Realtime Reporter

My commission expires: August 21, 2021
Notary ID: 20014025991

Exhibit 19

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GEOLOGICAL SURVEY CIRCULAR 95

March 1951

TALC INVESTIGATIONS IN VERMONT

PRELIMINARY REPORT

By

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and W. M. Cady

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
GEOLOGICAL SURVEY
W. E. Wrather, Director

Washington, D. C.

Free on application to the Geological Survey, Washington 25, D. C.

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TALC INVESTIGATIONS IN VERMONT
PRELIMINARY REPORT

ABSTRACT

Commercial talc deposits in Vermont are derived from ultramafic igneous rocks confined chiefly to a narrow belt that extends northward through the central part of the state from Massachusetts to Canada. This belt forms part of a more extensive belt that may be traced from Alabama to Newfoundland.

Bodies of ultramafic rock occur in phyllites, schists, gneisses, greenstones and amphibolites. Most of the ultramafic rocks are emplaced in or near greenstones or amphibolites. Knowledge of the regional structural and stratigraphic relations of the belt is incomplete, but in general the country rock forms a homoclinal sequence and exhibits little repetition of formations by folding.

The ultramafic bodies range in width from a few feet to about a mile, and in length from less than 100 feet to at least 3½ miles. They are of two types. Most of them, referred to here as the verde antique type, are completely serpentinized and more or less extensively steatitized. The second type, with which no commercial talc deposits are known to be associated, consists of partly serpentinized dunite or peridotite and minor pyroxenite, and commonly contains more or less chrysotile asbestos; this type occurs in one or two localities in southern Vermont and in several localities in northern Vermont. The mineral assemblage associated with the verde antique type of body reflects the effects of regional metamorphism alone, whereas the country rock bordering some bodies containing peridotite and dunite also reflects contact metamorphic effects attributable to the ultramafic intrusive.

The typical ultramafic body of the verde antique type contains steatite and grit, (a mixture of talc and carbonate at the margins), and a core of serpentinite. The steatite zone, at the outer border of the body, commonly ranges from a few inches to a few feet in thickness. The grit zone, between the steatite and serpentinite zones, is commonly several feet to a few tens of feet thick. There are, however, all gradations from ultramafic bodies formed almost entirely of serpentinite to bodies made up exclusively of grit and steatite. Inclusions, septa, and tongue-like projections of wall rock, which range widely in size, are common in the talc deposits; they are called "cinders" by the miners.

The structural features of the ultramafic rocks contrast rather markedly with those of the country rock. Serpentinite and grit show local schistosity that varies from poor to good, and steatite commonly exhibits a good schistosity. Some ultramafic masses appear to be folded. A layering or banding of undetermined origin is conspicuous at a few localities. Most serpentinite bodies are made up of rather distinct blocks of massive serpentinite as much as several feet across, termed shear polyhedrons, surrounded by thin, irregular layers of slickensided serpentintite. This feature contrasts markedly with the structural features of the country rock; it may be interpreted in several ways, but suggests that the serpentinite was intruded in solid state. Minor faults are found in a few ultramafic bodies. Current general conceptions of the intrusion, serpentinization, and steatitization of the ultramafic bodies are stated briefly; a definitive statement of the genesis of the ultramafic rocks is not attempted.

It is inferred from the wide distribution of localities in which ultramafic rocks are known and the general prevalence of steatitization at those localities, that the talc reserves in Vermont are large. The geographic positions of 145 localities are indicated. Suggestions for exploration and further geologic study are made.

INTRODUCTION

Commercial talc deposits, with a few exceptions, 1/ fall into two classes: those derived from or very closely associated with ultramafic igneous rocks and those formed from carbonate rocks of sedimentary origin. In commercial usage of the term pyrophyllite, whose properties are similar to those of talc, is commonly included with talc. Nearly all of the talc deposits in Vermont, and all of those of economic value in the state are of ultramafic origin.

Talc deposits related to ultramafic bodies were formed by the metamorphism and alteration of the ultramafic rocks, accompanied by minor steatitization of the country rock. Although such talc deposits are commonly in or closely associated with highly serpentinized ultramafic bodies, it is generally recognized that the processes of serpentinization and steatitization are unrelated and that serpentinization is an earlier process. Talc deposits derived from carbonate rocks are generally considered to have been produced by contact metamorphism of the carbonates where intruded by granitic rocks.

Talc derived from carbonate rocks is generally superior in "color" (whiteness) to talc associated with ultramafic rocks. But, many carbonate-derived deposits contain a large amount of tremolite which is undesirable in some talc products. Talc associated with ultramafic rocks commonly contains a relatively large amount of carbonate, and minor amounts of chlorite and serpentine, to which the generally inferior color of this type of talc is attributed.

Uses of Talc

Massive talc, called soapstone or steatite, 2/ has peculiar properties, particularly softness,

[1] A. E. J. Engel (written communication, March 29, 1950) states: "In California, for example, several economic talc deposits of appreciable size, purity, and value are formed as replacements of granitic and intermediate types of igneous rock. At Natural Bridge, N.Y., also, commercial 'talc' (actually talc and serpentine) has formed as a replacement of granite, syenite, and migmatite."

[2] For a definition of these terms, as used in this paper, see p. 3.

denseness, impermeability, and high heat-resistivity, which have made it useful to man from very early times for making pipes, ornaments, and cooking utensils. Talc has a wide variety of uses in modern industry. 3/ Soapstone is sawed into crayons and pencils which are used in foundries to mark white-hot steel and in the garment industry to mark fabrics. Because of its resistance to acids, soapstone is used extensively for laboratory tables and sinks. Its refractory properties make it suitable for molds for such materials as iron and glass. Its dielectric properties make it suitable for insulators and base plates for switchboards. The pure, dense, cryptocrystalline variety of steatite known as "lava grade" is valuable because it can be machined into intricate forms and then heat-treated to great hardness with negligible shrinkage. 4/

The soft varieties of talc which are not suitable for sawing or machining are ground to various degrees of fineness for a great variety of industrial uses. Some of the products in which ground talc is used are: paper, toilet and pharmaceutical preparations, pottery and porcelain, rope and twine, wall plaster, paints, electrical insulation, textiles, linoleum and oil cloths, soaps, roofing papers, rubber, lubricants, foundry facings, glass, agricultural insecticides, pipe-coverings, leather, cement, asbestos shingles, candy, shoe polish, and crayons. Ground talc is used also to polish some articles of food, such as coffee and rice.

The talc deposits of Vermont furnish varieties suitable chiefly for grinding, but small quantities of material suitable for pencils to mark structural steel are produced as a by-product. The largest producer of talc in Vermont reports the following consumption data, in terms of percentages of total sales, for 1949. 5/

	Percent
Paper	30
Rubber	18
Textiles	2
Roofing	6
Paint	5
Ceramics	1
Cosmetics	0.5
Insecticides	23
Asphalt filler	13
Miscellaneous	2.5
Total	100.0

Preliminary maps available

As a result of the studies made by the U. S. Geological Survey in the period August 1944-November 1945, the following maps have been prepared and placed in open file:

The Johnson talc mine:
- Geologic surface map, scale: 1 inch to 30 feet.
- Geologic map of the 200-foot level, scale: 1 inch to 30 feet.
- Structure sections, scale: 1 inch to 30 feet.

The Waterbury talc mine, preliminary maps 3-225:
- Geologic surface map, scale: 1 inch to 80 feet.
- Underground maps, including geologic maps and outline map of the underground workings, scale: 1 inch to 80 feet.
- Structure sections, scale: 1 inch to 80 feet. (3 sheets).

The Barnes Hill talc prospect, preliminary map 3-221.
- Geologic surface map, scale: 1 inch to 50 feet.

The Vermont Talc Co. quarry, Windham, preliminary map 3-221:
- Geologic surface map and structure sections, scale: 1 inch to 30 feet.

The Hammondsville talc quarry, preliminary map 3-221:
- Geologic surface map and structure sections, scale: 1 inch to 30 feet.

The Rousseau talc prospect, preliminary map 3-227:
- Geologic surface map and structure sections, scale: 1 inch to 50 feet; geologic map of the underground workings, scale: 1 inch to 20 feet.

The Mad River talc mine, preliminary map 3-227:
- Geologic surface map, scale: 1 inch to 50 feet; geologic map of the underground workings and structure sections, scale: 1 inch to 20 feet.

The Carleton talc quarry, preliminary map 3-227:
- Geologic surface map and structure sections, scale: 1 inch to 20 feet.

Copies of these maps, released as Strategic Minerals Investigations, Preliminary Maps, may be obtained by persons directly interested in the talc deposits upon application to the U. S. Geological Survey, Washington 25, D. C.

Scope of the report

The primary purpose of the report is to make available to interested persons the results of field work to date. The report is based almost exclusively on field studies and is chiefly a description of the structural relationships of the talc deposits. Interpretations based on laboratory data are not included, as laboratory work is still in progress.

Acknowledgments

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The Geological Survey is also indebted to a number of individual geologists, including P. H. Chang, P. H. Osberg, J. L. Rosenfeld, James Skehan, and J. B. Thompson, for their contributions to various aspects of the investigations. The authors are grateful to these persons for unpublished information concerning the regional geology, and for invitations to join in several interesting and informative field excursions.

[3] For a more complete discussion of the uses of talc see Engel (1949, pp. 1035-1038) or Gillson (1937, pp. 882-888).

[4] For further discussion of the properties and uses of "lava grade" steatite see Engel (1949, pp. 1036-1037; also references cited in his bibliography, pp. 1039-1041).

[5] Quoted with permission of Eastern Magnesia Talc Co., Burlington, Vt.

The authors benefitted from several days spent in the field with R. H. Jahns and T. P. Thayer of the Geological Survey. Jahns furnished unpublished information on the regional geology. M. R. Klepper and A. E. J. Engel of the Geological Survey read the manuscript critically and suggested numerous improvements.

Definitions of technical terms

The following technical terms have been variously used in the past by different geologists, and many are in common use among talc miners. Because some of the miners' terms are apparently peculiar to the Vermont talc industry and may not be known in other areas, the terms in this report are defined.

Ultramafic.-- The term is used throughout the report in a broad sense with reference to the igneous rocks peridotite, dunite, and pyroxenite and their derivities. Thus the term ultramafic body refers to the unaltered igneous rock, the serpentinite, the grit, and that part of the steatite which is an alteration of the original igneous body.

Serpentinite.-- The term is applied to rocks composed essentially of serpentine, after the usage of Lodochnikov (1933, p. 145), Phillips and Hess (1936, p. 333), and Selfridge (1936, p. 501). However, no genetic significance is attached to the term, as is apparently done by Phillips and Hess. The term serpentine is used here only in the mineral sense; it is used by miners in the sense of serpentinite as defined above. Verde antique is a trade term for serpentinite intricately veined with carbonate, and capable of taking a high polish so that it is suitable for use as an ornamental stone. Ultramafic bodies composed entirely of serpentinite, grit, and steatite are referred to as the verde antique type, and the serpentinite of such bodies is similarly distinguished.6/

Serpentinization is the process by which ultramafic igneous rocks were partly or completely altered to serpentinite. The term has no genetic significance as used here. The serpentinite zone includes the part of the ultramafic body that consists principally of serpentinite; it commonly forms the core of the verde antique type of ultramafic body.

Talc.-- The word talc is used here only in the mineral sense. Grit is a miners' term for a rock composed essentially of talc and carbonate. The grit zone is that portion of an ultramafic body composed almost entirely of grit; it lies between the serpentinite zone and the steatite zone. The term steatite is used in a broad sense to designate a rock that consists almost entirely of talc. The important distinction is that there is practically no carbonate; chlorite may be more or less abundant. 7/

The steatite zone is the portion of the ultramafic body and immediately adjacent altered country rock between the grit zone and the blackwall zone (see next paragraph) at the outermost edge of the ultramafic body. The term soapstone is restricted to steatite that is suitable for making sawn and shaped slabs. Pencil stock is a variety of soapstone with physical properties that make it suitable for "pencils" used in marking structural steel. Steatitization is the term applied to the process by which an ultramafic rock is partly or completely altered to talc or talc and carbonate. No genetic significance is attached to the term.

Blackwall.-- The altered country rock at the outer border of the steatite zone is called blackwall by the miners. In the majority of deposits the blackwall is chlorite schist, but in a few it is biotite schist. The blackwall zone is the altered part of the country rock between the steatite zone and the unaltered country rock; it lies outside of the ultramafic body.

Cinder.-- The term "cinder" is applied by miners to masses of schist within a steatite-grit body. Cinders may range in size from small fragments less than an inch across to very large tabular masses. In practice, any body of schist which is not demonstrably a part of the accepted hanging wall or footwall of a deposit is referred to as cinder.

Geographic distribution of the talc deposits

The talc deposits of Vermont are associated with ultramafic rocks that form part of a belt more than 2000 miles long, which extends from Alabama to Newfoundland. The belt lies in the terrane of crystalline rocks of the Appalachian Mountains.

In Vermont the ultramafic rocks are nearly all confined to a rather narrow belt that trends northward through the central part of the state from Massachusetts to Canada. The belt is almost 25 miles wide at its northern end, but it narrows rather markedly southward so that south of the Winooski River it is not more than 5 miles wide except at the latitude of Plymouth, where it broadens to a maximum width of 10 miles. Plate 1 shows the location of all known ultramafic bodies in Vermont; their distribution indicates the pattern of the ultramafic belt.

6 This application of the term *verde antique type of serpentinite* is somewhat more restricted than that of Bain (1936, pp. 1967-1974) who distinguishes two principal types of serpentinite: the "verde antique (white weathering) type" and the "red-weathering type." The verde antique type of serpentinite as defined by Bain on the basis of weathering characteristics is found to some extent in ultramafic bodies that contain relatively large masses of unserpentinized dunite and peridotite, but is found principally in bodies that contain only serpentinite of the verde antique type. The commercial verde antique occurs only in the latter, and the term verde antique may be logically restricted to such intrusives for the purpose of designating a type of ultramafic body. We believe that this usage does not violate that of Bain in any essential way, inasmuch as the verde antique type of serpentinite as defined by Bain is overwhelmingly more abundant in the verde antique type of ultramafic body as defined herein. We believe that the classification of the ultramafic bodies on the basis proposed (see pp. 4-5) has greater genetic and practical merit.

7 Various meanings have been attached to the word "steatite" in geologic literature. Priority and general geologic usage favor the definition given here, but in some geologic literature and especially in writings on high-quality ceramic talcs a different usage has evolved. The term "steatite" is used in the ceramic industry to denote a massive, compact, and comparatively pure variety of talc which must meet certain chemical and physical requirements for the manufacture of ceramics. The U. S. Bureau of Mines, from study of commercial shipments, fixes specifications at not more than 1.5 percent CaO, 1.5 percent Fe_2O_3, 4 percent Al_2O_3, and 5 to 10 percent non-talc minerals. Individual manufacturers' standards vary considerably, and some will accept as much as 6.5 percent CaO for certain uses (see Engel, 1949, p. 1037). In our opinion, it is best to define "steatite" in a broad sense, and to apply such terms as "ceramic-grade steatite" or "electrical-grade steatite" when it is desired to indicate a specific grade or type of steatite.

GEOLOGY

Most of the ultramafic rocks of Vermont occur in schists, phyllites, and greenstones on the east flank of the Green Mountain anticlinorium; but in the northern part of the state, north of the approximate latitude of the village of Johnson, several occurrences are known in similar formations west of the anticlinorial axis; for example, in Cambridge, Waterville, and Berkshire townships. C. H. Hitchcock and A. D. Hager (Hitchcock et al., 1861, pp. 539, 543, 788-789) report occurrences of both serpentinite and steatite in schists and gneisses in extreme eastern Vermont; these are apparently separated from those in the central part of the state by a broad synclinal belt of interbedded crystalline limestone and slate. Scattered occurrences of serpentinite, steatite, and grit are found in comparable rocks throughout both New Hampshire and Maine (Hitchcock, C. H., 1878; Smith, Bastin, and Brown, 1907, pp. 8-9). Further knowledge of the regional relationships of the ultramafic rocks must await completion of areal mapping now in progress.

The country rock

Rock types

The country rocks of the ultramafic belt include phyllites, schists, and gneisses, with intercalated schistose greenstones and amphibolites that represent altered volcanic rocks, both tuffs and flows, and intrusive rocks, chiefly sill-like dikes. Most of the ultramafic bodies are emplaced in greenstone or amphibolite or in schist and phyllite in the immediate vicinity of greenstones or amphibolites. Mafic dikes formed after regional folding and metamorphism intrude the ultramafic rock and country rock at several localities. There are no known granitic intrusive rocks, other than small felsic dikes at a few localities, associated with the ultramafic bodies.

The ages of the various formation into which the ultramafic rocks are intruded are uncertain, but it is probable that they range from Cambrian to Lower or Middle Ordovician.

Structure

Knowledge of the structural relations in the ultramafic belt is yet far from complete. Throughout most of the belt the rocks are vertical or dip steeply east or west on the east limb of the Green Mountain anticlinorium. The strike ranges from slightly west of north to northeast and averages about north. Schistosity and bedding are nearly parallel or parallel in most places where bedding is recognizable. There is remarkably little repetition of beds in folds, but very small folds with amplitudes of a few inches are present almost everywhere throughout the belt. At some localities there are folds with amplitudes of tens or hundreds of feet, and in a few areas, as much as a mile. These reflect the regional structural pattern, particularly that of the Green Mountain anticlinorium. However, such large folds appear to be the exception rather than the rule.

This rather simple homoclinal structure passes in the vicinity of Chester township into broad anticlinal arches and large overturned and recumbent folds. 8/ These structural features are responsible for the relatively greater width of the ultramafic belt in the latitude of Chester.

The ultramafic rocks

Composition and alteration

The original minerals of the ultramafic rocks have been nearly or completely altered at most localities, and only rare relics and ghosts of olivine and pyroxene remain. It is difficult or impossible to determine accurately the composition of the rocks when first emplaced. At several places in northern Vermont, however, and in at least one place in southern Vermont, the ultramafic rocks are, at least in part, remarkably unaltered (Bain, 1936, pp. 1968-1971). They apparently range from dunite, composed almost entirely of the mineral olivine, to pyroxenic peridotite in which the mineral pyroxene as well as olivine is abundant. Most of the ultramafic rocks were probably of peridotitic composition originally.

The ultramafic bodies may be divided into two types on the basis of absence or presence within each body of unserpentinized peridotite or dunite. Those that do not contain peridotite or dunite are called the verde antique type (see footnote on p. 3 for a fuller discussion). Those that contain unaltered peridotite and dunite correspond in a broad way to the red-weathering type described by Bain (1936, pp. 1973-1974).

All the commercial talc deposits in Vermont are associated with the verde antique type of ultramafic body, whereas none is known to occur in ultramafic bodies that are only partly serpentinized. On the other hand, cross-fiber asbestos appears to occur in appreciable quantities only in ultramafic bodies that contain unaltered dunite or peridotite, and is extremely rare or absent in the verde antique type. Small amounts of slip-fiber asbestos, commonly brittle and altered, have been found in association with a few talc deposits, and so have a few examples of what appear to be talc pseudomorphs after cross-fiber asbestos.

Several investigations of ultramafic rocks (Selfridge, 1936, pp. 497-498; T. P. Thayer, oral communication, August 1949) from widely separated regions, supplemented by incomplete petrographic studies made in connection with the current investigation in Vermont, indicate that the serpentine mineral in the verde antique type of ultramafic body is antigorite, whereas the serpentine mineral in serpentinite associated with unaltered dunite and peridotite is a non-asbestiform variety of chrysotile. 9/

[8] Thompson, J. B., Oral communication, September 1948.

[9] G. C. Selfridge (1936, pp. 468-469) defines the serpentine group of minerals as consisting of two mineral species, serpentine and antigorite. He considers chrysotile to be an asbestiform variety of the species serpentine.

Bain's conclusion that the "white-weathering" and "red-weathering" serpentinite are two genetic types (1936, pp. 1978-1979) may be interpreted to support the foregoing definition. He identifies the serpentine mineral in both types as antigorite, but presents no supporting data. It is commonly difficult to distinguish the serpentine minerals by optical characteristics (see Selfridge, 1936, pp. 484-496), and in thin-section serpentine may easily be mistaken for antigorite.

The weathering characteristics of the two types of ultramafic rocks generally serve to distinguish them quickly and easily. The verde antique type of serpentinite weathers to a characteristic pale greenish-white or light buff color. Dunite and peridotite, and commonly the associated serpentinite, weather to a red-brown color referred to as "buckskin." The buckskin color may not be an inherent character of the mineral serpentine but the effect of the presence of abundant small relics of olivine, whose weathering gives the entire rock a red-brown color.

The verde antique type of serpentinite shows various degrees of alteration to grit and steatite. The wide range in degree of steatitization is striking. Many of the serpentinite bodies, such as those at the Mad River and Waterbury mine localities (localities 46 and 41) 10/, show only relatively thin zones of grit and steatite at the margins. At the other extreme are the talc deposits at the Johnson mine, the Rousseau prospect, and Sterling Pond (localities 28, 23, and 25), which are, throughout much of their extent, entirely altered to grit and steatite; only small residual cores of serpentinite occur at the Johnson mine and the Sterling Pond localities, and no serpentinite is known at the Rousseau prospect.

In addition to the changes within the ultramafic body proper, associated changes in the country rock at the contact with the ultramafic body are evident. The latter changes include the alteration of the country rock to chlorite or biotite schist referred to as the blackwall. The serpentinites and country rocks that border them exhibit a rather well-defined zonal arrangement as an effect of these changes. An ideal sequence from the center of such an ultramafic body outward (to be described in more detail later) is serpentinite, grit, steatite (or talc-actinolite rock), and blackwall, each of which occupies a more or less definite zone. The blackwall grades into unaltered country rock.

The mineral assemblages in the different zones differ considerably among the ultramafic bodies of the verde antique type. At one extreme is an assemblage considered to be characteristic of low temperatures of formation; at the other extreme an assemblage characteristic of higher temperatures.

In the low temperature assemblage the blackwall zone is composed almost entirely of chlorite, the steatite zone is almost entirely talc, and the grit zone is talc and carbonate. In the higher temperature assemblages the blackwall zone is chiefly biotite, part or all of the steatite zone is composed of actinolite with minor talc, and the grit zone is composed of flaky talc, carbonate, and radiating acicular talc probably pseudomorphic after enstatite or anthophyllite (Phillips and Hess, 1936, pp. 344-347; see also Bain, 1934, pp. 398-399). The mineral assemblage of the serpentinite zone consists of serpentine and carbonate, with minor magnetite, and shows little or no variation within the range of temperature effects encountered in the belt of ultramafic rocks.

The metamorphic grade of the ultramafic bodies of the verde antique type appears to vary sympathetically with that of the country rock. Moreover, the metamorphic grade of the country rock is fairly uniform over moderately large areas, remote from and also close to these ultramafic bodies. In other words, it is regional in scope and apparently not produced by a contact metamorphic action of the ultramafic body; but contact metamorphic zones a few feet in width were observed in the country rock adjacent to some of the ultramafic bodies that contain dunite and peridotite.

Size and shape

The ultramafic bodies range in width from a few feet to about 1 mile, and in length from less than 100 feet to at least 3½ miles. They vary widely in shape. Most of them are lenticular or pod-shaped, and pinch and swell markedly in both plan and section; some are more or less tabular bodies that have been folded; and a few very irregular ones are branched, folded, and faulted.

Many ultramafic bodies of the verde antique type exhibit minor protuberances, or small tongues of steatite, which branch out for short distances from the main body. In most deposits these irregularities are minor, and the tongues are commonly only a few inches thick and several feet long. However, in a few deposits and notably at the Johnson mine, these irregularities are prominent features, which make extensive drilling and exploration necessary in order to keep the workings in the main ore bodies.

In many places it is difficult to determine the exact nature of these features, but it is believed that at least three different modes of origin are involved: Some probably are completely altered tongues of serptntinite; others reflect alteration of schist in zones especially susceptible because of composition or accessibility to solutions; and a few apparently reflect post-mineral movement of the soft steatite into fractured zones and in fault slivers. Probably most of the smaller tongues are of replacement origin.

The ultramafic bodies in Vermont are comparatively free of folds, although most of them exhibit small folds a few inches in amplitude. A few talc deposits, however, are clearly associated with larger folds with amplitudes of tens or hundreds of feet. This is especially true at the Johnson mine, the Rousseau prospect, Sterling Pond, the Waterbury mine, and the Hammondsville quarry (localities 29, 23, 25, 41, and 117). The structural features at these localities range from simple, broad, anticlinal arches as at Hammondsville, to very irregular, tight folds as at Johnson.

Distribution of steatite and grit

Relatively thin zones of steatite and grit occur at the margins of a central, pod-like mass of serpentinite in the simple, or idealized, verde antique type of ultramafic body. The grit zone is commonly not more than a few feet thick, and the steatite zone a few inches to a few feet. Grit and steatite are commonly thickest along the "keels" of the serpentinite pods at "rolls" and folds in the contact, and at narrow strictures in the ultramafic bodies (see Phillips and Hess, 1936, pp. 338-339). The serpentinite core of the simple as well as of the strucurally

10 Locality numbers refer to pl. 1.

more complex types of deposit is irregularly embayed by more or less completely steatitized zones. In some deposits, notably at Barnes Hill (locality 40), the grit is very irregularly distributed in large interconnected masses throughout the zone normally occupied by the serpentinite core, as well as in its usual position at the margins of the deposit. At a few localities, for example, at the Johnson mine, the Rousseau prospect, and Sterling Pond (localities 28, 23, and 25) the ultramafic bodies are almost entirely altered to steatite and grit. In such deposits the grit zone is as much as 100 feet wide.

The position of the boundary of an ultramafic body before steatitization is difficult to determine. All of the grit and most of the steatite probably were derived from serpentinite, and it is believed that the original contact between ultramafic rock and country rock lay near the outer border of the steatite zone. At most places, probably not more than a few inches of the outer part of the steatite zone is derived from country rock, but locally, especially in very irregular deposits, the steatite zone appears to extend as much as 10 feet outward into the country rock beyond the original border of the ultramafic mass. Long, narrow tongues of steatite commonly extend for a considerable distance along the strike at the ends of a lenticular ultramafic body. They may swell locally into small, lenticular steatite masses nearly isolated from, but not unrelated to the original ultramafic body. Undoubtedly, a large part of each of these tongue-like extensions is steatized country rock.

Inclusions and nearly isolated septa and tongue-like projections of more or less completely chloritized country rock are common and locally abundant in the grit and steatite. These are referred to by the miners as "cinders." Some of the cinders are small, irregular fragments less than an inch through and occur in clusters. More commonly, the cinders form rather widely separated masses, the smaller of which are spheroidal and as little as 6 inches in diameter. The larger cinders form tabular masses as much as 20 feet thick; their greatest observed dimension is 400 feet. Most of the cinders are probably inclusions or tabular projections from the walls formed during emplacement of the ultramafic body, but some appear to form tongues and slivers faulted from the wall rock after formation of the grit and steatite.

Figure 1 shows the distribution of steatite, grit, and serpentinite in a typical ultramafic body and a small, nearly isolated lens.

Structural details

The structural deatils of the ultramafic rocks are varied in contrast with the rather uniform schistosity of the enclosing country rock formations. The sequence of development of some features of ultramafic rocks cannot be determined until critical petrographic studies and a geologic map of the ultramafic belt are completed. The more common isolated structural features are banding, schistosity, and shear polyhedrons.

Banding .-- A few serpentinite bodies, notably at the Barnes Hill and Belvidere Mountain localities

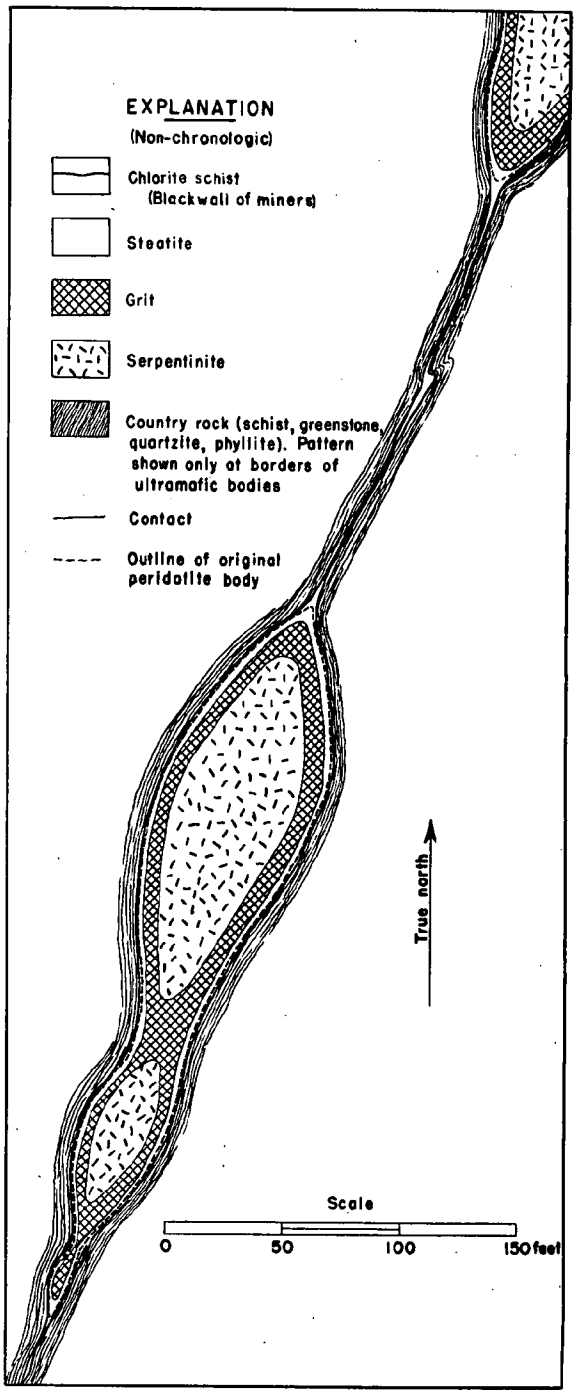

Figure 1.—Idealized sketch map of a typical steatite-grit-serpentinite body showing the distribution of rock types, and illustrating small, nearly isolated lenses of steatite in the country rock. The width of the steatite zone outside the borders of the original ultramafic body is slightly exaggerated.

(40, 9), exhibit a conspicuous banding. The banding is produced by alternating light- and dark-colored layers which range in thickness at Barnes Hill from one-sixteenth to one-fourth of an inch, and at Belvidere Mountain from one-fourth of an inch to at least 1 inch. It is best preserved in the serpentinite, but can be distinguished in many outcrops of grit at Barnes Hill where it shows up especially well on weathered surfaces. The bands may be primary (original layers) or they may be a later shear feature. Possibly both types exist.

Schistosity. The ultramafic bodies are all partly schistose, and orogenic movement since their emplacement is indicated. Serpentinite, grit, and steatite are all affected, although not to the same degree; furthermore, the range in degree of schistosity is rather wide. In most of the deposits the steatite exhibits good schistosity; the grit is commonly non-schistose, but locally shows poor-to-good schistosity; and the serpentinite is normally non-schistose, although in some places it shows rude-to-excellent schistotosy at the borders of and locally within the serpentinite mass. Their schistosity commonly is parallel to the general trend of the schistosity of the country rock, but is locally more variable. At some localities, for example, at the Johnson mine (locality 28) and at the Carleton quarry (locality 124), the steatite shows a local cleavage that roughly parallels the axial planes of folds as much as 30 feet in amplitude.

Shear polyhedrons. Almost all of the suitably exposed serpentinite bodies of the verde antique type that were examined exhibit a striking feature. Close-packed units of massive, essentially unsheared serpentinite, irregularly polyhedral in shape, ranging in size from a mean diameter of a few inches up to a limit unknown but certainly as great as several feet, lie within thin zones of highly sheared serpentinite. The sheared zones are irregular in shape and attitude and do not conform to any apparent system. The massive, unsheared units are termed shear polyhedrons.

This feature contrasts markedly with the well-defined bedding schistosity of the country rock. Its significance is not clear because several interpretations are possible and none is adequately supported by data now at hand. (See pp. 38a-38c for further discussion.)

Faults

Minor faults are found in many of the ultramafic bodies. They are commonly difficult to recognize because they are small and poorly exposed, and the rocks affected lack distinguishable markers with which to gage displacement. Extensive minor faults are favorably exposed, however, in the Johnson, Waterbury, and Mad River talc mines (localities 28, 41, and 46). These faults strike slightly east of north, roughly parallel to the strike of the ultramafic bodies. The faults are nearly vertical at the Waterbury and Mad River mines; at the Johnson mine they dip from 30 degrees eastward to 30 degrees westward, most of them at low angles. Zones of gouge and fault breccia as much as 4 feet thick are formed along some of the fault planes. Slickensides, deep grooves, and gouges indicate that they are chiefly diagonal-slip faults. The total displacement is commonly indeterminate, owing to the lack of markers. Relative movement of the foot-wall and the hanging-wall rarely can be demonstrated. At the Waterbury mine, however, where a mafic dike serves as an excellent marker, and probably at the Mad River mine, the east side moved northward and downward; the strike slip of the fault at the Waterbury mine is about 135 feet.

Minor faults are much more prevalent in and near the ultramafic rocks than in the country rock. These faults probably reflect a tendency of the steatitized ultramafic bodies, in contrast with the country rock, to yield by slip rather than by flexure.

Origin

There is considerable disagreement among geologists concerning the origin of ultramafic rocks and their derivatives. Some believe that the rocks were intruded as magmas. Others, who believe that magmas of ultramafic composition do not exist, postulate that the rocks were formed by crystal accumulation and were intruded in the solid or partly solid state. Serpentinization is generally considered to be a hydrothermal or a deuteric process accomplished relatively soon after intrusion. In contrast, some exponents of solid intrusion believe that serpentinization is independent of deuteric or hydrothermal action and is an integral part of the mechanism of intrusion.

Shear polyhedrons (see p. 36), which are particularly well formed in serpentinite bodies of the verde antique type, may be interpreted to support the conception of intrusion in the solid state, but the evidence is not conclusive. Several interpretations are more or less interrelated.

One is that regional stresses, which originated entirely outside of the serpentinite bodies, were responsible for the formation of the shear polyhedrons, and that the contrast between the structural features of the ultramafic bodies and of the country rock is due solely to the differences in physical characteristics of the two rock types. Another interpretation is that the shear polyhedrons are the result of expansion within the ultramafic body during serpentinization, most of the adjustment that accompanied expansion having taken place along the shear zones, formed concurrently with serpentinization, which bound the polyhedrons. In both these interpretations, the polyhedrons are considered to have formed without appreciable movement of the ultramafic body as a whole. A third interpretation, which combines some features of the other two, explains the shear polyhedrons more satisfactorily: Regional compression, perhaps aided by expansion during serpentinization, resulted in extensive transport of the ultramafic rocks, particularly in directions parallel to the bedding, to form thin tabular and podlike intrusive bodies. The smallest structural unit believed to have been involved in such transport and emplacement is the shear polyhedron, whose sheared and finely brecciated borders reflect the conditions of movement. Such extensive movement of the serpentinite, with consequent rotation and jostling of the unsheared units as they moved past one another, may explain the diverse orientations of the shear zones and the approach to equidimensional form of the shear polyhedrons. Serpentinization, facilitated by stress and

and by the shear zones which furnished access to water supplied from the surrounding country rock, is conceived to have taken place contemporaneously with transport and emplacement, essentially in the manner suggested by Sosman (1938, p. 359) and by Bowen (1947, pp. 269-271; 1949, pp. 454-457). Under such conditions of genesis, ultramafic bodies intermediate between the verde antique type and the partly serpentinized dunite or peridotite type may have been formed, although none has yet been recognized in the current studies.

The lack of contact metamorphic effects in the country rock that borders the verde antique type of ultramafic body may be cited as further evidence favoring an origin by intrusion in the solid state. On the other hand, the contact metamorphic zones observed adjacent to some of the ultramafic bodies that contain dunite or peridotite (see p. 5) suggest that the latter type of body was derived more directly from a magma, the heat of which accounted for the contact metamorphic effects. Possibly the ultramafic bodies that contain dunite or peridotite represent the parent type from which the verde antique type of ultramafic body was derived.

Steatitization is generally recognized as a later process, independent of serpentinization, and is commonly attributed to the effects of hydrothermal solutions from underlying magmas. It is possible, however, that steatitization is an expression of regional metamorphism.

TALC RESERVES

Indicated and inferred reserves of talc are apparently large, as is shown by the widespread occurrence and the general prevalence of steatitization of ultramafic bodies in Vermont. They are probably adequate to meet normal as well as emergency demands for many years to come. A discussion of proven talc reserves is not practicable because the mining companies do not attempt to block out ore reserves several years in advance. One of the purposes of the investigations now in progress is to derive a detailed estimate of the indicated and inferred talc reserves and of proven reserves when data may become available.

TALC DEPOSITS

Geographic location of known deposits

To the best of our knowledge, the following localities comprise all of the known ultramafic bodies in Vermont. Nearly all of them probably have talc associated and many are potentially talc producers. Four are now being mined for talc, and many have been intermittently prospected or mined in the past. Several ultramafic bodies, especially in northern Vermont, are known to contain asbestos, and one is an active producer.

We have examined about 45 of the localities. Descriptions of the rest have been taken from the literature or have been furnished by members of the Geological Survey and others recently or now engaged in mapping several quadrangles in the belt of ultramafic rocks. The localities are numbered to conform with the key to their general location on Plate 1.

Deposits examined in the course of this investigation are marked with an asterisk(*). Thirty-three of the talc deposits examined to date and indicated by a double asterisk (**) are described in the section "Description of deposits." These and deposits located by geologists now mapping in the area are accurately located by reference to some feature on the Geological Survey topographic maps, scaled about 1 inch to the mile. Other deposits described in the literature of the region may not be exactly placed, although descriptions and map points have been translated as nearly accurately as possible to topographic maps. Descriptions of locations are quoted if they are adequate, but many are vague. Inaccuracies in early topographic maps and the small-scale of many locality maps have contributed further to the difficulties of making accurate locations.

Quadrangle maps may be obtained from the U. S. Geological Survey, Washington 25, D. C. at a price of 20 cents each.

Enosburg Falls quadrangle

1. C. H. Hitchcock (in Hitchcock, Edward, Hitchcock, Edward, Jr., Hager, A. D., and Hitchcock, C. H., 1861. p. 542) reports a "bed of steatite... in Berkshire [township]*** near the west line in the south part of town." Hitchcock shows this locality to be approximately 2¼ miles N. 20° W. of Enosburg Falls on the Geological Map of Vermont.

Jay Peak quadrangle

2. Hitchcock (1861, p. 542) reports a "bed of steatite" in Berkshire township "rather east of the middle of the town." He locates this area about 2⅛ miles due east of Berkshire village on the Geological Map of Vermont.

3. Hitchcock (1861, p. 542) reports "a bed of steatite, serpentine, and actinolite at Wright's Mill in Richford [township]." This locality is shown to be approximately in the village of South Richford in Hitchcock's geologic atlas of New Hampshire (1878). It is probably about half a mile due north of elevation 852 on the quadrangle map.

4. Hitchcock (1861, p. 541) reports "a bed of steatite in the east part of Enosburg [township]." He places this locality about 2⅛ miles S. 70 ° E of the village of East Enosburg on the Geological Map of Vermone, but the locality is shown only 1⅛ miles S. 65° E. of East Enosburg in his geologic atlas of New Hampshire (1878). The latter is published on a larger scale and is presumably more nearly accurate, although the planimetric detail of both maps is poor in this area.

5. ** A talc deposit, known locally as the Montgomery Center talc prospect, is exposed in west-central Montgomery township 1.45 miles S. 62° W. of the junction, in Montgomery Center, of state routes 118 and 58.

6. Hitchcock (1878) shows a body of "serpentine and

steatite" in the southwestern part of Montgomery township, about 1 mile northeast of the southwestern corner of the township.

7. Hitchcock (1861, p. 541) reports "a bed of steatite in Belvidere [township], 3 miles northeast of the meeting house. The bed is about six rods wide where it has been quarried. The central part of the bed is rather a coarse serpentine." He shows presumably the same body on the border between Averys Gore and Belvidere township in his geologic atlas of New Hampshire (1878). Comparison with the quadrangle map indicates that the planimetry of the atlas is probably incorrect here.

8. Hitchcock (1861, pp. 543-544) states that he was informed of, but did not visit, "an immense mass of serpentine at Hazens Notch."

9. ** The Belvidere Mountain asbestos quarry is in a large ultramafic body lying on the boundary between Eden and Lowell townships, on the southeast flank of Belvidere Mountain. The present quarry is located 0.6 mile N. 10° W. of Corez Pond.

Irasburg quadrangle

10. Bain (1936, fig. 1) shows an ultramafic body in the northwestern part of Troy township, about 0.75 mile N. 25° W. of the road triangle in North Troy. According to C. H. Hitchcock (1861, p. 542) "a bed of steatite, from one to eight feet wide" is associated with this body.

11. An ultramafic body, apparently at least a mile long and several hundred feet wide, is reported (Bain, 1936, fig. 1) in northeastern Troy township, about 2 to 2½ miles east of the road triangle in North Troy.

12. A small ultramafic body is located in northern Troy township 2¼ miles S. 30° E. of the road triangle in the village of North Troy (Bain, 1936, fig. 1).

13. Bain (1936, fig. 1) shows an ultramafic body about 2 miles long from north to south on the boundary between Jay and Troy townships; the center of the body is half a mile west of the West Road School, 2½ miles south of North Troy. This is apparently the serpentinite mass that Hitchcock (1861, p. 542) says contains "steatite beds" on the west side, and also veins of "chromic iron ore" up to 2 feet wide.

14. A narrow ultramafic body about 2 miles long terminates at the north about midway between River Road School and East Hill School in Troy township (Bain, 1936, fig. 1).

15. * A small ultramafic body lies 0.3 mile due east of the road triangle in Troy village.

16. ** An ultramafic body crops out in west-central Troy township, 0.8 mile S. 65° E. of the road triangle in Troy village.

17. ** Another ultramafic body crops out in west-central Troy township, 1.1 miles N. 70° E. of the road triangle in Troy village.

18. Bain (1936, fig. 1) shows a nearly continuous belt of ultramafic rocks that extends from about 2 miles northeast of Troy village to a mile east of Lowell village. Hitchcock (1861, p. 542) reports "a bed of steatite" about a mile east of Lowell village, which is probably associated with this belt of ultramafic rocks.

19. * Serpentinite crops out in central Lowell township at an old dam site on the East Branch of the Missisquoi River 0.5 mile northwest of the road triangle in Lowell village.

20. * The eastern edge of a large ultramafic body crops out on the Hazens Notch Road 1 mile northwest of the road triangle in Lowell village. The deposit, as shown by Bain (1936, fig. 3), is at least one-fourth mile wide and extends both north and south of the Hazens Notch Road for at least 1½ miles. Hitchcock (1861, p. 542) states that there is talc associated with the "west range of serpentine" at Lowell; he apparently refers to this locality.

21. Hitchcock (1861, p. 542) reports that "half a mile west of the Troy [township] line, and two and a half miles north of the south line of Westfield [township], there is a bed of steatite." He shows the locality as 1.4 miles S. 21° E. of Westfield village on the Geological Map of Vermont.

Mount Mansfield quadrangle

22. ** A talc deposit, on which the abandoned Waterville talc quarry is located lies in northern Waterville township 3.45 miles N. 12° E. of the center of Waterville village. This is probably the locality stated by C. H. Hitchcock (1861, p. 541) to contain "stone of most excellent quality," and of which he further says, "We have considered it the finest in the State."

23. ** The Rousseau talc prospect is in Cambridge township, 2.1 miles N. 59°E. of Cambridge Junction.

24. C. H. Hitchcock (1861, p. 541) reports that "in Cambridge on Sterling Mountain, near its top upon the east side, there is a bed of steatite." He states further that "much steatite of excellent quality occurs near the center of the old town of Sterling."

25. ** Several large bodies of grit, steatite, and some serpentinite crop out near Sterling Pond, in the northwest part of Stowe township, about 1.2 miles due east of Smugglers Notch.

Hyde Park quadrangle

26. C. H. Hitchcock (1861, p. 541) reports that "there is a bed of excellent steatite in Eden [township]. It is on Mr. Phillip's land, one mile west of the church. It is 15 feet wide and runs N. 16° E. "Hitchcock (1878 shows this deposit 0.7 mile west of the center of the village of Eden Mills in his geologic atlas of New Hampshire.

27. * A small outcrop of talc is exposed 2.4 miles N. 28°E. of the center of the village of Johnson about 0.3 mile N. 5° W. of Christy School in Johnson township. It is less than 10 feet wide and between 15 and 20 feet long.

28. ** The Johnson talc mine, largest in Vermont,

lies in the northeast part of Johnson township, 2.58 miles N. 39° E. of the center of Johnson village.

29. A talc deposit is reported (oral communication from Mr. Heming Franz, Johnson, V., 1945) about a mile west of the Johnson mine.

30. **A small talc deposit is exposed about 500 feet south of the mill of the Eastern Magnesia Talc Co., in Johnson village; the locality is 0.75 mile S. 60° W. of the center of the village.

Hardwick quadrangle

31. C. H. Hitchcock (1861, p. 541) reports a "bed of steatite on Lowell Mountain" in Eden. The location is uncertain, but possibly the reference is to the Lowell Mountains in northeastern Eden township.

Camels Hump quadrangle

32. Hitchcock (1861, p. 541) reports talc on top of Woodward Mountain on the boundary between Waterbury and Bolton townships. The probable location is 6.2 miles N. 37° W. of the junction in Waterbury village of State Route 100 and U. S. Route 2.

33. * A body of serpentinite crops out in the southeastern part of Duxbury township, 0.5 mile N. 30° W. of the church in the village of South Duxbury.

34. Hitchcock (p. 541) reports that "near Waterbury Street," now known as Waterbury village, "there is [a bed of steatite] twelve feet wide belonging to H. H. Pinneo."

35. Hitchcock (p. 541) reports that "there is another bed [of steatite] two miles north of Pinneo's, upon the same stream, belonging to W. Eddy."

Montpelier quadrangle

36. * A small body of grit is exposed about 0.2 mile southwest of the village of Colbyville in Waterbury township.

37. Hitchcock (p. 541) reports a "bed of steatite... three-fourths of a mile south of the village of Stowe."

38. It is reported locally that talc was found in a well on the farm of Craig Burt, about 2 miles northeast of Stowe village.

39. Hitchcock (p. 541) reports a "bed [of steatite] from ten to fifteen feet wide... at Barret and Gilman's ledge north of Waterbury Center."

40. ** A large body of talc and serpentinite is exposed on Barnes Hill in northeastern Waterbury township. The deposit is 2.2 miles N. 35° E. of the road triangle at Waterbury Center. Two occurrences reported by C. H. Hitchcock (1861, p. 541), "a bed of steatite in Stowe [township] near [the] Waterbury [township] line", and a "bed of steatite in the north part of [Waterbury] town[ship], upon D. Gray's land", probably may be identified with the Barnes Hill deposit.

41. ** The Waterbury talc mine is in northwestern Moretown township on the south bank of the Winooski River, 2.0 miles S. 45° E. of the junction in Waterbury village of State Route 100 and U. S. Route 2.

42. * A small outcrop of grit lies approximately half a mile west of the ultramafic body at the Waterbury mine. The locality is 0.8 mile S. 45° W. of the Rock Hill School in the northwest part of Moretown township.

43. Local reports place a small talc prospect about half a mile south of the highway intersection in Middlesex village.

44. C. H. Hitchcock (1861, p. 543) states that the Rev. S. R. Hall showed, on a manuscript map, a "bed of serpentine" in the east part of Middlesex township. Hitchcock shows this locality about 6 miles due north of the city of Montpelier, and about three-fourths mile east of the village of Shady Rill on the Geological Map of Vermont.

45. * A small body of grit and steatite is exposed 1 mile due east of the summit of Mt. Hunger in Worcester township.

Lincoln Mountain quadrangle

46. ** The Mad River talc mine is in northeastern Fayston township, 2.0 miles S. 63° W. of the center of the village of Moretown.

47. * A small grit and steatite outcrop lies 2150 feet S. 10° W. of the Mad River mine, on the right (east) bank of Shepard Brook and about 50 feet south of a road bridge over the brook. This outcrop is possibly on the same talc deposit as the Mad River mine.

48. Bain (1936, fig. 1) shows an ultramafic body about 1 mile south of the Mad River mine, probably between a quarter and half a mile due west of North School in northwestern Waitsfield township. A resident of Warren village informed us that talc occurs at this locality.

49. C. H. Hitchcock (1861, p. 541; see also Hager, A. D., p. 789) reports "a bed of steatite... upon Mrs. Jocelyn's land... one mile southeast of the village of Waitsfield." He gives the length and width of the body as 90 by 8 feet.

50. ** An ultramafic body crops out 0.25 mile due east of the church in Warren village. This is probably the locality to which C. H. Hitchcock (1861, p. 541) refers in reporting the occurrence of "a bed of steatite *** four feet wide near the River village in the south part of town."

51. ** A small serpentinite body is exposed 0.75 mile N. 24° E. of the four corners at East Warren. The outcrop is approximately 100 feet west of B. M. 1371.

52. E. C. Jacobs (1916, p. 240) reports the occurrence of steatite "on Mr. Edgar Towne's farm" in eastern Warren township. This locality is 0.4 mile southwest of South Hill School.

53. Edward Wigglesworth (1916, p. 285) reports a

serpentinite body on the east slope of Scrag Mountain, "5½ miles north of the Roxbury quarries and near the western border of Northfield [township]."

54. ** A small abandoned talc quarry is located in southern Roxbury township, 40 feet west of State Route 12 A and 330 feet north of the boundary between Addison and Washington Counties.

Barre quadrangle

55. * A small body of grit and serpentinite crops out in Roxbury township 0.88 mile S. 66° W. of the four corners in Roxbury village.

56. * A small ultramafic body is exposed 1.2 miles N. 42° W. of the four corners in Roxbury village.

57-65. Bain (1936, fig. 1) shows ultramafic bodies approximately as follows with respect to the four corners in Roxbury village:

57. 0.85 mile N. 75° W.
58. 1.45 miles N. 9° W.
59. 0.9 mile N. 21° W.
60. 0.7 mile N. 25° W.
61. 0.75 mile N. 35° W.
62. 0.45 mile N. 44° W.
63. 0.35 mile S. 50° W.
64. 0.6 mile S. 28° W.
65. 0.7 mile S. 28° W.

66. ** An ultramafic body is exposed 1.1 miles S. 28° W. of the four corners in Roxbury village.

67. ** An ultramafic body crops out 1.1 miles S. 25° W. of the four corners in Roxbury village.

68-71. Bain (1936, fig. 1) shows ultramafic bodies southwest of the four corners in Roxbury village approximately as follows:

68. 1.00 mile S. 31° W.
69. 0.95 mile S. 28° W.
70. 0.85 mile S. 30° W.
71. 0.45 mile S. 35° W.

72. ** The East Granville talc deposit lies about 4½ miles south of the Roxbury area, immediately west of the east border of Granville township and about 1 mile from the junction of the east border of Granville township and the south border of Roxbury township. An abandoned mine in the deposit is 0.3 mile due east of the center of the village of East Granville.

Rochester quadrangle

73. ** The Rochester verde antique quarry is in northern Rochester township, 2.95 miles due north of the square in the center of Rochester village.

74. ** The Williams talc mine, now abandoned, lies in the eastern part of Rochester township, 2.65 miles S. 70° E. of the square in the center of Rochester village.

75. ** A large serpentinite and talc body is exposed half a mile N. 30° W. of the Williams mine at Cushman Hill.

76-78. Jacobs (1914, p. 409) shows, on a crude sketch map, several other small talc deposits in the vicinity of the Williams mine. They are:

76. The Hubbard prospect, about 0.4 mile north of Cushman Hill.
77. A small prospect about 0.5 mile south of the Williams mine.
78. The McPherson mine, about 1 mile S. 15° W. of the Williams mine.

79-82. P. H. Osberg (oral communication, February 1949) reports ultramafic bodies northeast of Hancock village as follows:

79. 2.6 miles N. 80° E.
80. 3.15 miles N. 82° E.
81. 3.05 miles N. 83° E.
82. 2.45 miles N. 84° E. An ultramafic body that contains considerable talc is exposed at this locality, which is known locally as "Talc Ledge."

83-88. Bain (1936, fig. 1) shows ultramafic bodies east and southeast of Hancock village approximately as follows:

83. 3.2 miles due east
84. 3.3 miles due east
85. 3.35 miles S. 87° E.
86. 3.3 miles S. 84° E.
87. 3.5 miles S. 82° E.
88. 3.55 miles S. 78° E.

89. Osberg (oral communication, February 1949) reports an ultramafic body 2.95 miles S. 77° E. of Hancock village.

90. Bain (1936, fig. 1) shows an ultramafic body 3.55 miles S. 76° E. of Hancock village.

91-93. Osberg reports (oral communication, February 1949) ultramafic bodies southeast of Hancock village as follows:

91. 3.6 miles S. 74° E.
92. 3.7 miles S. 69° E.
93. 3.9 miles S. 55° E.

94. The Greeley talc mine, now abandoned, lies in western Stockbridge township about 1.1 miles N. 46° W. of the center of the village of Stockbridge. Bain (1936, fig. 1) shows a large body of serpentinite and two smaller masses a few hundred feet to the south of the large body. The north end of the large body lies at an elevation of about 800 feet above sea level and is immediately west of the grade of the abandoned White River Railway.

Randolph quadrangle

95. C. H. Hitchcock (1861, p. 539) reports that "there...is one [bed of steatite] in the village [of Bethel], upon the east side of White River.... Its length is twenty four rods."

96. Hitchcock (p. 540) reports that "In the westerly part of the town[ship (Bethel)] there is another bed of steatite."

97. Hitchcock (p. 540) reports that "In the north part of Bethel there is a bed of laminated talc." He shows this locality as 6 miles N. 48° W. of Bethel village on the Geological Map of Vermont.

Mt. Cube quadrangle

The deposits in this quadrangle lie about 20 miles to the east of the main belt of ultramafic rocks, from which they are separated by a barren strip.

98. C. H. Hitchcock (1861, p. 539) reports an occurrence in Thetford township, that "near the middle of the east side of this town... is an irregular bed of soapstone, about eight feet thick."

99. Hitchcock (p. 539) reports that "fifty rods west [of locality 98] is another mass of impure steatite."

100. Hitchcock (p. 543) reports a large mass of serpentinite in the northern part of Norwich and the southern part of Thetford townships. "It is about half a mile wide where it crosses the town line. Its eastern limit is just one mile from the Connecticut River. It is probably of great length."

Woodstock quadrangle

101. C. H. Hitchcock (1861, p. 539) reports "a bed of steatite" in Bridgewater township, "one mile north of the center of the town... on the west bank of the North Branch of the Ottauquechee River." The location has been confirmed by P. H. Chang (oral communication, February 1949) as 1 mile N. 5° W. of the bridge across the North Branch at Bridgewater Center.

102. Hitchcock (p. 539) reports another "bed of steatite" in Bridgewater township, 2 miles south of locality 101 and on the west bank of North Branch. He states that it is of little consequence.

103. Hitchcock (p. 539) reports a large serpentinite body in eastern Plymouth township. This deposit, with which there are associated several "steatite beds," is said by Hitchcock to extend southward for nearly 3 miles, into the Ludlow quadrangle. It is shown by E. L. Perry (1929, fig. 2, p. 40) at the village of Five Corners and south of there.

104. Hitchcock (1878) shows an ultramafic deposit on the west slope of Southgate Mountain near the summit, about 1 mile N. 25° E. of Bridgewater Corners.

105. Hitchcock (1878) shows an ultramafic body on the east slope of Cobb Hill near the summit, about 1 mile N. 40° E. of Bridgewater Center.

106. E. L. Perry (1929, fig. 3, p. 9) shows a body of "steatite" in western Bridgewater township 1.65 miles N. 63° E. of West Bridgewater village and "about one hundred yards north of the McElroy farmhouse."

107. Perry (1929, fig. 3, p. 9) shows another body of "steatite" in western Bridgewater township 1.65 miles N. 83° E. West Bridgewater village and "about a thousand yards south" of locality 106.

Hanover quadrangle

The ultramafic rocks in the Hanover quadrangle, like those in the adjoining Mt. Cube quadrangle, lie outside of the ultramafic belt proper.

108. C. H. Hitchcock (1861, p. 543) reports a "very compact serpentine rock, half a mile north of the Norwich depot on the railroad."

Ludlow quadrangle

109. Hitchcock (1861, p. 539; see also Hager, A. D., 1861, p. 787) reports steatite "in the southeast part of [Plymouth township] half a mile west of the meeting house [in Plymouth Kingdom?]." An attempt to find the deposit was unsuccessful, but an approximate location was obtained from a local resident, the door-sill and foundation of whose house contain blocks of grit of excellent quality, said to have been obtained from a quarry on this deposit more than 100 years ago.

110** A small body of talc is exposed in the northeastern part of Ludlow township, 0.8 mile S. 22° E. of North Hill School.

111. J. B. Thompson (oral communication, September 1948) reports a small body of talc in northeastern Ludlow township, 0.5 mile N. 50° E. of the road bridge over the Black River in Ludlow village.

112. ** A small body of talc, in which is an abandoned talc mine known as Valentine No. 2, is exposed in northeastern Ludlow township. 0.85 mile N. 70°E. of the road bridge over the Black River in Ludlow village.

113. ** Another small body of talc, in which is an abandoned talc mine known as Valentine No. 1, is exposed in northeastern Ludlow township, 0.9 mile N. 85° E. of the road bridge over the Black River in Ludlow village.

114. ** A talc deposit lies in eastern Ludlow township, 1.0 mile S. 57° E. of the road bridge over the Black River in Ludlow village.

115. * One of the larger ultramafic bodies in Vermont lies in southeastern Ludlow and southwestern Cavendish townships. The deposit is 3.5 miles long and as much as a mile wide. It is exposed along State Route 103, which bisects the body, in several road cuts between points half a mile and 1½ miles west of the village of Proctorsville.

116. J. B. Thompson (oral communication, September 1948) reports a small ultramafic body 2 miles S. 45° E. of the road bridge over the Black River in Ludlow village.

117. ** The Hammondsville talc quarry is located in eastern Reading township, 0.2 mile northeast of B.M. 969 in the village of Hammondsville.

118. J. B. Thompson (oral communication, September 1948) reports that a small talc deposit lies about half a mile west of the Hammondsville quarry.

119-123. Several other talc deposits were noted by J. B. Thompson (oral communication, September 1948) as follows:

119. Southwestern Weathersfield township at Quarry Pond, 0.9 mile due west of the village of Perkinsville.
120. Western Chester township, about 0.1 mile east of the junction of the townships of Ludlow, Andover, and Chester; a small deposit.
121. Eastern Andover township, about 0.1 mile west of the boundary between Andover and Chester townships and 2 miles south of the junction of Ludlow, Andover, and Chester townships; a small deposit, possibly a continuation of that at locality 120.
122. Eastern Andover township, 0.8 mile N. 45° E. of the village of Simonsville; a small body.
123. Eastern Andover township, 1.1 miles N. 40° E. of the village of Simonsville; a small body.

124. ** The Carleton talc quarry, now abandoned, is in Chester township, 2.2 miles N. 85° W. of Chester Depot.

Saxtons River quadrangle

125. J. L. Rosenfeld (oral communication, October 1948) reports a small body of serpentinite in northern Windham township, 1.6 miles N. 80° E. of the junction in the village of North Windham of State Routes 11 and 121.

126. ** The Vermont Talc Co. quarry is in a large ultramafic body in northern Windham township, 1.2 miles S. 60° E. of the junction in North Windham village of State Routes 11 and 121.

127. ** A large ultramafic body crops out in northern Windham township, 1.8 miles S. 55° E. of the road junction in North Windham village.

128. ** A talc deposit is exposed in northern Windham township 1.8 miles S. 65° E. of the road junction in North Windham village.

129. ** The Barton talc quarry, now abandoned, is in southwestern Chester township, 3.7 miles S. 48° W. of Chester Depot.

130. ** The Davis or Holden quarry, now abandoned, lies in southern Chester township, 2.1 miles S. 5° E. of Chester Depot.

131. C. H. Hitchcock (1861, pp. 542-543) reports a large serpentinite body "east of the village of Windham." He shows the locality as half a mile northeast of Windham Center on the Geological Map of Vermont.

132. Hitchcock (p. 542) reports a body of serpentinite in southeastern Windham township "northwest of [locality 133] about a mile and a half." This locality is probably about half a mile northeast of Burbee Pond.

133. J. L. Rosenfeld (oral communication, October 1948) reports serpentinite and grit 1.3 miles N. 45° E. of the village of South Windham.

134. Rosenfeld (oral communication, October 1948) reports outcrops of serpentinite in the trail 1.8 miles N. 85° E. of Burbee Pond, in southeastern Windham township.

135. Hitchcock (1861, p. 538) reports "One of the largest [steatite bodies] is in ... the southeast corner of [Windham township] upon the farm of Simeon Pierce... half a mile south of Pierce's house... . The bed is fifteen rods long and four rods wide... . It occupies the crest of the hill." Rosenfeld (oral communication, October 1948) locates the old Pierce house 1.75 miles N. 53° E. of South Windham village.

136. ** Several quarries, now abandoned, are opened on a presumably single deposit of steatite in southern Grafton township, 2.1 miles S. 15° E. of the center of Grafton village.

137. Hitchcock (1861, p. 536) reports "a tubercular mass of steatite of small size, in the east part of Townshend [township], upon the land of David Beamis... . The widest part of the bed is 30 feet." This location is confirmed by Rosenfeld (oral communication, October 1948) as 0.67 mile N. 80° E. of the pond at the village of Simpsonville.

138. Rosenfeld (oral communication, October 1948) reports a small steatite body 0.7 mile N. 83° E. of Lily Pond in southern Athens township.

Wilmington quadrangle

139. James Skehan (written communication, October 1949) reports a steatite body 0.95 mile S. 77° E. of the four corners in West Marlboro village.

140. Hitchcock (1861, p. 535) reports steatite "on the top of a hill in the west part of [Marlboro township], north of the Methodist church, [on] the property of Hosea Ballou." A small quarry was opened in the southern end, where "the bed is 50 feet wide... The total length of the bed was estimated at 25 rods." Probably the locality is about 0.2 mile N. 30° E. of the four corners in West Marlboro village.

141. Skehan (written communication, October 1949) reports a steatite body 0.6 mile N. 10° W. of the four corners in West Marlboro village. This is probably a locality referred to by Hitchcock (1861, p. 535): "Half a mile north [of locality 140] on the land of Ward Belus... in the bed of a brook there are two small beds of steatite... each fifteen feet wide."

142. Skehan (written communication, October 1949) reports a steatite body 1.3 miles N. 18° E. of the four corners in West Marlboro village.

143. Skehan (written communication, October 1949) reports a steatite body 0.6 mile due south of the junction of the townships of Dover, Newfane, and Marlboro. This is the locality reported by Hitchcock (1861, p. 535) "in Marlboro [township] in the northern part of town... upon the land of Clark Worden." Hitchcock (p. 535) states that this body is 20 rods long and 4 rods wide.

144. Hitchcock (1861, p. 542) reports a large body of serpentinite in eastern Dover and western Newfane townships that extends from near the junction of Dover, Newfane, and Marlboro townships "for a distance of 3 miles along the line of Dover and Newfane [townships]. Where Rock River cuts through the serpentine in Dover and Newfane, the serpentine is nearly a mile wide."

Brattleboro quadrangle

145. Hitchcock (1861, pp. 535-536) reports steatite in Newfane, which he considers as possibly a continuation of the ultramafic body at locality 144. The deposit is described as situated on a hill in the northwest part of Newfane at an altitude of about 1620 feet, and as at least half a mile long and not less than 12 rods wide at the north end. The locality is probably about 5 miles N. 40° W. of the junction of Marlboro Branch and Baker Brook at Williamsville.

Descriptions of deposits

Most of the deposits that the authors have examined are described briefly in the following section. The descriptions include directions for access, a statement of the size and shape of the body, if known, and a general description of the character of the ultramafic rocks. Several of the deposits have been mapped in considerable detail and are more completely described.

The locality numbers correspond with those in the foregoing section.

Montgomery Center talc prospect Locality 5

The Montgomery Center talc prospect lies in west-central Montgomery township, 1.45 miles S. 62° W. of the junction in Montgomery Center of State Routes 118 and 58. The deposit is in a small saddle at an altitude of 1170 feet. Total relief in the general area is about 1200 feet; in the immediate vicinity of the deposit, it is low to moderate.

To reach the locality from the village of Montgomery, drive westward on State Route 118 for 0.5 mile from the center of the village and turn left (south) a little east of the bridge over West Hill Brook. Continue southward about 2½ miles to an old lane on the left (east) side of the road. The talc prospect is at the east end of this lane, about 0.6 mile from the road. The lane is impassable by auto.

The nearest railroad is the Central Vermont at East Berkshire village, 6 miles to the northwest.

The prospect.-- Grit crops out about 150 feet north of the lane which provides access to the prospect, along the base of a small ledge that faces southward. Near the west edge of the ledge is a shaft, inclined about 60° to the north; its depth is unknown because it is now filled with water. Three small pits have been opened at the foot of the ledge to the east of the shaft; grit and steatite are exposed in two of these. Although the extent of the underground workings is unknown, the small size of the dump indicates that mining operations were probably not extensive.

Geology.-- Outcrops are insufficient to determine the size and shape of the deposit. Grit is exposed in the shaft, in two of the pits on the north side of the lane, and in two small [outcrops] about 20 feet south of the lane. Although these exposures seem to indicate a maximum width of about 180 feet, the grit outcrops north and south of the lane are probably on two separate deposits whose aggregate thickness is much less than the 180-foot maximum, the length is indeterminate. Possibly the two series of outcrops represent a single, tabular body that is folded.

Serpentinite is nowhere exposed in the deposit, and insofar as can be determined from the limited exposures and from an examination of material on the dump, it has been altered entirely to grit and steatite. The talc is of good quality although the surficial material examined was stained deeply brown from weathering of iron-bearing carbonate.

The country rock in the immediate vicinity of the prospect consists of quartz-mica schist and dark, blue-green, vitreous quartzite. The bedding and schistosity are nearly or quite parallel. They vary widely in attitude. The strikes range from north to west, the dips from vertical to nearly horizontal. Probably the predominant attitude is strike northwest, dip steep to the northeast.

The structural relationships of the ultramafic rocks to the country rock are obscure. That the country rock is folded is shown by small folds visible in individual outcrops and by the wide range in attitude exhibited by both bedding and foliation on a larger scale throughout the area. Foliation in the steatite indicates that the ultramafic rock has been subjected to stress. It is not possible to say at present, whether the deposit is a tabular mass that has been folded or whether it is an irregular tabular body or lens (or two separate lenses) injected into previously folded rocks and affected by only the late stages of movement.

Reserves.-- It is impossible to arrive at a quantitative estimate of reserves because the size and shape of the deposit cannot be predicted except within very wide limits on the basis of work to date. If the deposit is a single, large lenticular body, reserves are probably several hundred thousand tons. If, on the other hand, the deposit is a folded tabular body, reserves are possibly only a few thousand tons.

Belvidere Mountain asbestos quarry, Locality 9

The Belvidere Mountain asbestos locality is on the southeast flank of Belvidere Mountain in northern Eden and southwestern Lowell townships. The operating quarry is in Lowell township, 0.6 miles N. 10° W. of Corez Pond. The old quarry is about 1 mile S. 75° E. of the present quarry. The altitude of the operating quarry is about 1300 feet; the old quarry, about 2150 feet. Total relief within a radius of 1 mile of the old quarry is about 2100 feet.

To reach the operating quarry from the village of Hyde Park, drive north on State Route 100 for 11.1 miles from the junction with State Route 15 to the center of Eden Mills. Turn half left off Route 100, continue northeastward 0.15 mile, and turn half left

again. Drive 3.5 miles north to the entrance to the quarry. Turn left and continue on to the mill and quarry offices.

The nearest railroad is the St. Johnsbury and Lamoille County at Hyde Park village, about 15 miles southwestward by road.

The geology of the locality has been described by Marsters (1905, pp. 419-446).

We have made two short trips to the locality. The ultramafic body appears to be at least a mile long and several hundred or perhaps a few thousand feet wide. The trend of the long axis of the body is about east or east-northeast. Both serpentinite and dunite occur. Details of occurrence of asbestos have not been investigated. Talc is reported to occur at the locality, but we saw none. Within the ultramafic body in tabular or lenticular masses, and at least locally along the contacts there is a lime-silicate rock, composed principally of garnet, diopside, and vesuvianite.

Reserves. Total reserves of asbestos and talc are not known, but the asbestos reserves are likely sufficient for more than 10 years, at the present rate of production of about 30,000 tons annually 11/.

Locality 16

An ultramafic body of unknown, but probably large size is exposed in west-central Troy township, 0.8 mile S. 65° E. of the road triangle in Troy village. The talc deposit lies at an altitude of about 960 feet, a little below the brow of a hill on the east slope of the Missisquoi valley. Relief in the immediate area is moderately low and totals less than 200 feet in a radius of half a mile.

To reach the locality from the village of Troy, drive eastward on State Route 100 for 0.5 mile from the road triangle at the center of the village and turn right (south) immediately after crossing the Missisquoi River. Continue southward for about 0.4 mile. The talc crops out about 1000 feet east of this point, a little below the brow of the hill.

The nearest railroad is the Canadian Pacific at Newport Center, about 5 miles to the northeast.

Geology.-- Only a few minutes were spent at this locality. The size and shape of the deposit are not known, but grit crops out for a distance of at least 200 feet in a north-south direction, and for at least 70 feet east-west. Serpentinite crops out a short distance southeast of the grit outcrops.

The talc is of good quality but locally the grit contains abundant specular hematite. This would undoubtedly destroy the value of the talc unless beneficiation should be practicable.

The country rock in the immediate vicinity of the grit outcrops is not exposed, but a short distance to the west light-colored volcanic rocks are well-exposed.

11 Quoted by permission of the Vermont Asbestos Mines, written communication, May 19, 1950.

Reserves. -- The possibilities are good that a large deposit of talc exists at this locality, although an accurate estimate of reserves is not possible. The commercial value depends largely upon the extent of hematite throughout the deposit, and whether beneficiation is practicable.

Locality 17

A large ultramafic body crops out on the land of Arnold Peters, 1.1 miles N. 70° E. of the road triangle in Troy village. Relief in the immediate vicinity of the deposit is about 400 feet.

The locality is only a few minutes drive from Troy village. Drive eastward on State Route 100 a distance of 1.1 miles from the road triangle in the center of the village. The Peters' farm is on the left-hand (north) side of the road. The talc deposit crops out about 600 feet north of the house; the outcrops extend from the bed of a westward-flowing creek to at least midway up the southwestern slope of the hill on the right bank of the creek.

The nearest railroad is the Canadian Pacific at Newport Center, about 5 miles to the northeast.

Geology. -- The exact size and shape of the ultramafic body are not known, but it is almost certainly large, because the grit outcrop in the stream valley is at least 200 feet wide, and serpentinite and grit crop out about 1000 feet to the north. The grit examined was of good quality. It is believed that the ultramafic body is extensively steatitized.

No exposures of country rock were noted near the ultramafic rocks.

Reserves. -- A quantitative estimate of reserves is not attempted, but it is believed that the deposit is large. Moreover, it is possible that the steatite, grit, and serpentinite at this locality and at locality 16 are part of one large deposit. Should this prove to be true, the total reserves of talc and grit probably are great.

Waterville talc quarry, Locality 22

An abandoned talc and soapstone quarry in northern Waterville township lies 3.45 miles N. 12° E. of the center of Waterville village. The quarry is at an altitude of about 1000 feet above sea level on the eastern slope of Bears Den Hill. Relief in the immediate vicinity of the quarry is moderate; total relief within a radius of a mile is about 1100 feet.

The locality can be reached from the village of Waterville by driving northeastward from the road junction near elevation 493 (as shown on the topographic map) in the center of the village for a distance of 3.1 miles on the road to Belvidere Junction. Turn left (west) on the side road opposite elevation 699 (Hyde Park quadrangle) and continue westward for 0.2 mile; turn right (north) and drive 0.55 mile to the most northerly of two houses several hundred feet apart. The old quarry is approximately 1900 feet N. 50° W. of this house.

The nearest railroad is at Cambridge Junction, about 7 miles to the southwest, where the Central Vermont and the St. Johnsbury and Lamoille County railroads join.

The quarry.-- The quarry workings are now slumped, overgrown with brush, and filled with water, so that it is difficult to assess the former operations. It is apparent, however, that operations were on a small scale. Some of the quarry walls reveal that part of the product was extracted as sawn blocks for soapstone, but the ruins of an old mill in which there were several millstones indicate that part of the product was marketed as ground talc.

Near the eastern contact of the deposit are two small quarries. The southernmost is the larger, being about 60 feet long by 40 feet wide and of unknown depth. The smaller quarry measures about 20 by 30 feet and lies 15 feet to the north of the larger one. It is evident that most of the soapstone came from these two quarries.

Approximately 80 feet to the northwest, along the western contact, is an irregular pit about 40 feet in diameter. This pit was probably the source of steatite and grit used for a ground talc product.

Geology.-- The deposit has about 130 feet maximum width, but it is pinched down to less than 40 feet at the southern end of the exposure. The exposed length of the body is at least 160 feet. The deposit, insofar as could be seen, consists of grit and steatite, with considerable actinolite along the eastern contact. No serpentinite is exposed. The country rock is quartz-mica schist.

The eastern contact of the deposit, exposed for a distance of about 60 feet, is fairly regular in attitude, striking N. 30° to 35° E. and dipping 70° to 75° westward. The western contact, exposed intermittently over a distance of about 160 feet, is variable in attitude: the strike at the northern end ranges from N. 10° E. to N. 55° E., the dip from 40° westward to 70° northwestward; at the center of the exposure the strike of the contact is N. 25° W., the dip 60° southwestward; at the southern end of the exposure the strike of the contact is N. 20° E., the dip 40° northwestward.

The schistosity of the country rock is apparently everywhere conformable with the contact of the ultramafic body. A well-developed schistosity is found locally in the steatite and grit. The strike of this schistosity is almost parallel to the general strike of the country rock (about N. 20° to 30° E.), but the dip is vertical or steep to the east, in contrast to the schist which dips moderately to steeply westward.

Reserves.-- On the basis of brief examination, the deposit does not appear to contain a significant reserve. However, the grit is of good quality, and detailed study might disclose additional reserves.

Rousseau talc prospect, Locality 23

The Rousseau talc prospect is in northern Cambridge township, 2.1 miles N. 59° E. of Cambridge Junction. The deposit is on the south side of the Lamoille River near the base of the northernmost mountain of the Sterling Range. An old prospect adit lies at an altitude of about 530 feet above sea level and 70 feet above the flood plain of the Lamoille. Maximum relief within a radius of a mile is about 800 feet.

For access to the prospect from Johnson village, drive westward on State Route 15 for 5.9 miles from the center of the village. The dump of the talc prospect is plainly visible about 200 feet south of the highway.

The St. Hohnsbury and Lamoille County Railroad passes within a few hundred feet of the prospect.

The prospect.-- A prospect adit has been driven southward in the grit-steatite body along the eastern contact with the schist for a distance of 125 feet. Twenty-five feet south of the adit entrance, a 20-foot cross-cut extends to the western contact, and an 80-foot drift continues southward along that contact, making a total of a little more than 200 feet of workings. Six diamond drill holes that total almost 1100 feet have been drilled at the prospect.

Geology.-- Surface exposures, underground workings, and diamond drill cores show the talc body to be wedge-shaped. The deposit is 100 to 125 feet wide at a depth of 180 feet below the adit, measured along the dip. It narrows upward at a fairly constant rate to a thickness approximately 40 feet at the altitude of the adit. At a point 100 feet southeast of the adit, the talc body is not more than 5 feet thick. Within a few hundred feet farther to the southeast, it is believed to pinch out entirely or to become very thin, at least at the surface. The known length of the deposit is 350 feet.

The entire ultramafic body, as nearly as can be determined, is altered to grit and steatite. The material is of excellent quality, although much of that near to the surface is stained brown from weathering of iron-bearing carbonate.

The country rock consists of quartz-mica schists and greenstones. Locally, the schist contains garnet, biotite, and albite.

Diamond drill cores indicate that the attitudes of both the foot- and hanging-walls of the deposits are fairly constant below the level of the adit. The strike of both varies generally from about north to N. 5° W. The dip of the hanging-wall is approximately 25° westward; the dip of the footwall varies from 45° to 60° westward.

Above the level of the adit, at an altitude of about 570 feet, the hanging-wall is involved in several folds with amplitudes of 10 to 20 feet and widths from crest to crest as much as 40 feet. It is not known whether the foot-wall is folded sympathetically.

The talc deposit lies on the western limb of the Green Mountain anticlinorium. The contact of the ultramafic body is conformable with the foliation and bedding wherever exposed. The general strike of bedding and foliation is slightly west of north; the dip is, in general, 20° to 40° to the west. Small scale

drag folds, including those in the hanging wall of the ultramafic body, show a rather consistent gentle plunge to the south, comparable with the plunge of the Green Mountain anticlinorial axis in this latitude. The plan of the fold pattern of both the small drags and of the larger folds is dominantly such as to indicate that they are on the western limb of a southward-plunging anticline, which would seem to indicate that the minor folds are genetically related to the formation of the Green Mountain anticlinorium.

Reserves. -- The Rousseau prospect is one of the more promising talc deposits of Vermont. Indicated reserves are conservatively estimated at 500,000 tons on the basis of underground prospecting and diamond drilling. Inferred reserves are at least that large and may well total several million tons.

Sterling Pond talc deposits, Locality 25

Several large talc deposits are exposed near Sterling Pond, in the northwestern part of Stowe township, about 1.2 miles due east of Smugglers Notch. The deposits are at altitudes of 3000 to almost 3600 feet above sea level. Relief within a radius of a mile of Sterling Pond is about 1700 feet, and topography is rather rugged.

Because of the altitude, snowfall is heavy and snow accumulates to great depths. Winters are long and cold. On the average, the area is snow-free for only about 4 or 5 months each year.

Access to Sterling Pond is by foot trail. From Stowe village, drive northwestward on State Route 108 for approximately 10 miles to the height of land at Smugglers Notch. About 600 feet north of the height of land, and directly opposite the site of a souvenir stand, a well-marked (white-painted blazes) trail leads from the road eastward to Sterling Pond, which is 1¼ to 1½ miles away by trail. The ascent is about 1000 feet.

One of the greatest drawbacks to development of the deposits is the relative remoteness of the area from shipping facilities. The nearest road, through Smugglers Notch, is more than a mile distant across rugged terrain, and the nearest railway shipping point is at Cambridge Junction, about 7 miles to the north.

Geology. -- The country rock is predominantly quartz-mica schist in which small albite porphyroblasts are common and locally abundant. Garnet also is abundant locally, and some biotite was noted. The strata everywhere exhibit folds which range from a fraction of an inch to several hundred feet across. The bedding and schistosity dip gently to moderately east or west in folds which plunge about 15° southward. The locality is about a mile east of the axis of the Green Mountain anticlinorium.

Grit is exposed in at least seven localities within a mile of Sterling Pond. Grit of excellent quality crops out about 500 feet west of the pond for a distance of 200 feet along the trail between Smugglers Notch and Sterling Pond. The eastern contact with the schist was not found, but the western contact strikes about west-northwest and dips at a moderate angle northeastward.

Grit crops out at a point 300 feet southwest of the outlet of the pond, in the trail (marked by blue-painted blazes) leading southward from Sterling Pond over Spruce Mountain. The schistosity in the grit strikes about northeast and dips 45° to 50° to the southeast. Southeastward from the outcrop in the trail (and about normal to the strike of the schistosity), grit crops out intermittently over a distance of at least 80 feet. A serpentinite outcrop of 20 or 30 feet wide is exposed about 100 feet southeast of the grit outcrop in the trail. Southeastward beyond the serpentinite, or about 150 feet southeast of the outcrop of grit in the trail, is another outcrop of grit. Schist is exposed 10 feet or so to the southeast of this last grit outcrop. The wallrock schistosity, and therefore probably the margins of the ultramafic body, strike northeast and dip 30°- 40° to the southeast.

Grit crops out almost continuously along the entire southeast shore of Sterling Pond, and some grit occurs on the peninsula that juts out from the western side of the pond. The outcrop width of the grit along the southeast shore, measured normal to the strike of the body, is 200 feet. The general attitude of the body is: strike east-northeast, dip 15° to 20° southward.

Grit crops out about 500 feet east of the pond for about 20 feet along the trail between Sterling Pond and Madonna Peak.

A talc body at least 200 feet wide and more than 750 feet long is exposed about 1500 feet east of the pond, on the trail to Madonna Peak and at the divide between a north- and a south-trending intermittent stream. The eastern contact of the ultramafic body strikes north and dips 45° eastward.

Two other outcrops of grit and steatite occur between the saddle and Madonna Peak; one about 200 feet east of the saddle, and another at an altitude of 3580 feet about 500 feet south of the summit of Madonna Peak.

Probably the first three occurrences described represent one tabular body, involved in folds several hundred feet across. The other outcrops are probably on separate masses, although it is possible that they all represent one sheet-like body repeated in folds.

The grit in this locality is of very good quality. The high outcrop ratio of grit and steatite to serpentinite indicates that the ultramafic rocks have been extensively steatitized.

Reserves. -- All indications are that reserves at this locality are very large, at least several million tons. The greatest drawback to their development is the relative inaccessibility of the area.

Johnson talc mine, Locality 28

The Johnson talc mine, the largest in Vermont, is in northeastern Johnson township, 2.85 miles N. 39° E. of the center of Johnson village. The altitude at the southern end of the deposit is about 950 feet; at the northern end, about 1300 feet; the altitude of the collar of the shaft is approximately 1050 feet. Relief in the immediate vicinity of the mine is rather low, and of the general area, moderate; total relief within a radius of a mile is about 1000 feet.

To reach the mine from Johnson village, drive northeastward on State Route 100 C from its junction with State Route 15 for a distance of 2.8 miles, to the four corners. Turn left (west) at the schoolhouse and continue westward for 0.8 mile, to a fork in the road; take the right-hand fork and continue about 0.6 mile to the mine.

The nearest railway is the St. Johnsbury and Lamoille County at the village of Johnson, about 4½ miles to the southwest by road.

The mine. -- Before the beginning of modern operations by the present owners (Eastern Magnesia Talc Co.), the deposit was worked intermittently and on a rather small scale by several operators. These operations date probably to the early 1900's, possibly earlier. Most of the old workings are now inaccessible, being caved or flooded. The various groups of workings are now designated Mine No. 1, Mine No. 2, Mine No. 3, and Mine No. 4.

Mine No. 1 includes the 1st, 2d, 3d, 4th, 5th, and 6th levels. Levels 1 to 4 were worked from an old shaft, long since caved, located 120 feet east of the so-called Mine No. 1 shaft, now also caved and inaccessible. Levels 1, 2, 3, and 4 were mined entirely by hand methods, and the workings were not extensive. The levels were spaced probably not more than 40 feet apart vertically.

The 5th and 6th levels were mined from Mine No. 1 shaft, near the south end of the ultramafic body. The shaft was inclined about 46° southward. The altitude of the 5th level is 876 feet 12/ at the shaft. The workings consist of a system of rooms and pillars over an area 650 feet long north-south and 200 feet wide. These openings are now caved and inaccessible.

The 6th level is at an altitude of 796 feet (mine datum) at the shaft. Workings total about 8000 feet, but only 3500 feet of these at the northern end of the level are now accessible, the southern part of the level being caved and flooded.

Mines No. 2 and 3 were worked by small, vertical shafts not more than 50 feet deep. Both were mined by hand methods, and the workings associated with each were not more than 200 feet in extent. At present, Mine No. 2 is flooded; Mine No. 3 has been broken into by stoping operations from the 200-foot level below.

Mine No. 4 includes the 200-foot level and the 170-foot level the latter a small drift no longer being mined. The 200-foot level is mined from the Mine No. 4 shaft, inclined 45° southward. The designation "200-foot level" refers to the distance in feet below the collar of the shaft, measured along the incline. The altitude of the 200-foot level is 940 feet at the shaft. The workings total more than 7500 feet. The Mine No. 4 shaft recently has been extended downward to the old 6th level so that mining operations may be resumed on that level.

Mining operations at the Johnson mine are on a moderate scale (about 50,000 tons annually) but are efficient and chiefly mechanized. The drifts are driven almost entirely in grit, which is massive and holds up well with little or no timbering. Pneumatic drilling equipment is used throughout the mine. Broken rock at the working face is loaded with pneumatic mucker.

The stoping method is a flexible system of overhand benching, readily modified to suit the size and shape of the talc body being mined. In general, a steeply inclined raise is driven from the side of a drift near the roof. The raise is continued into the grit body for as far as is practicable, and near to the hanging wall of the talc deposit. A chute is installed at the bottom of the raise about 5 feet above track level, and a grizzly installed in the raise about 25 feet above the track. Thereafter, the grit and steatite are mined back from the raise in a series of benches so that it runs to the grizzly and chute by force of gravity. Near the end of mining operations in a given stope, especially if the body is fairly flat-lying at that location, it is sometimes necessary to use an electrically powered scraper to get the rock to the grizzly.

At the chutes, the broken rock is loaded into 1-ton cars and hauled by battery-driven locomotives to the foot of the shaft, where the cars are emptied into a 1-ton skip. The skip is hoisted to the surface by an electrically-powered winch, and dumped into a sorting device which separates the material into coarse, medium, and fine. From the bins the ore is dumped into trucks and hauled to the mill at Johnson village, about 4½ miles distant by road.

Geology. -- The talc deposit has a known length underground of 3500 feet, and extends northward beyond the known extent for an unknown distance under a cover of glacial drift. The southern limit of the deposit is definitely established.

At the southern end, the deposit is a single, simple, lenticular mass about 180 feet thick, that strikes N. 20° E. and dips 75° to the east. Northward, however, the deposit becomes more complex. A septum of schist appears on the 5th and 6th levels about 300 feet north of the southern end of the deposit, and divides it into an eastern and a western body. Farther north the relations become more and more complex, so that the cross-cut at the foot of the shaft on the 200-foot level discloses five talc bodies. Probably all are separate masses; that is, they are not a single tabular body repeated by folding. It is possible, however, that they branch from a single body and that they join downward. Elsewhere, folds further complicate the form of the deposit; and irregular septa (called "cinders" by the miners) that range widely in size are distributed sporadically throughout the talc bodies. The general picture, then in the northern end of the mine, is of a series of pinching and swelling, irregular tabular bodies which strike a little east of north and dip steeply

[12] All elevations are relative to mine datum; to correct approximately to sea level datum, subtract 35 feet from the altitude given.

to moderately eastward, and which are locally complicated by the existence of folds and by numerous included septa of schist.

The ultramafic mass has been very largely altered to grit and steatite, with a few relatively small remnants of serpentinite. There is an elliptical, pipelike remnant of serpentinite at the south end of the body, about 250 feet long and 75 feet wide, which plunges to the north at 45° to 50°. The size and shape of this serpentinite mass is inferred from limited surface exposures and from mining company maps of the 5th and 6th levels which are inaccessible in the vicinity of the serpentinite. Serpentinite has been encountered at three or four places in the northern end of the mine in relatively small- to moderate-sized masses, more or less altered locally to grit. Elsewhere, the ultramafic body has been entirely altered to steatite and grit.

The country rock consists of quartz-mica schist and micaceous quartzite; the schist is locally graphitic. At the contact with the ultramafic body the country rock is altered to chlorite schist, the blackwall, for a distance of 0.5 to 2 feet outward from the contact. The contact of the blackwall with the steatite is abrupt, but locally gradational over a distance of a fraction of an inch or a few inches. The blackwall grades into the unaltered schist, commonly over a distance of a few inches, but locally over a distance of a foot or more.

The sequence outward from any of the masses of serpentinite, except where subsequent faulting has disturbed the original relationship, is the normal one: serpentinite, grit, steatite, blackwall (chlorite schist), and unaltered schist. Locally, however, post-steatite faulting has cut out one or more of the zones so that serpentinite may be in contact with blackwall, or steatite with unaltered schist, etc.

The serpentinite is fine-grained, dark green and, at least where exposed, nonschistose. Where favorably exposed, the serpentinite exhibits shear polyhedrons which have been more or less completely obliterated by the alteration to talc and carbonate. Serpentinite grades into grit, in most places rather abruptly, but also commonly through distances of a foot or more.

The grit, which is medium to light gray in color, is an aggregate of talc and carbonate. The carbonate, which forms 30 to 50 percent of the rock, is scattered rather uniformly in grains one-eighth to three-fourths of an inch in diameter throughout a fine groundmass of talc. Commonly the carbonate is anhedral, but locally a rather large percentage of grains have subrhombic outlines. The grit is commonly nonschistose.

The steatite is dark gray to light gray-buff in color and is composed almost entirely of fine-grained talc. It generally shows a poor to good schistosity nearly or quite parallel to the contact with the blackwall, and to the schistosity of the country rock. In some places the schistosity of the steatite departs by a few degrees from that of the country rock which is almost always, except at fault contacts, parallel to the contact. At a few places where the steatite is involved in folds a few feet or tens of feet in amplitude, a schistosity roughly parallel to the axial plane of the fold is present in the steatite.

On the average, the schists strike about N. 20° E. and dip steeply to the east or are vertical in surface exposures. Underground, the dips are in general somewhat less steep. This apparent difference in dip is possibly a reflection of resistance to weathering and erosion, which has favored the preservation of outcrops of areas with steep schistosity.

Throughout most of the underground workings the schist represents a homoclinal sequence with tops of beds to the east. Bedding and schistosity everywhere appear to be essentially parallel, and dip an average of about 60° to the east, with only minor folds represented by flattening of the dips to horizontality or slightly to the west. Such folds are commonly not over a few feet from crest to crest. In some places, however, there is evidence of rather tight folds. In other places, such as in the rolls common in the hanging wall of the talc deposit, where chloritization has completely destroyed the original structures of the schist, it is difficult to demonstrate that the feature is a fold and not an intrusive phenomenon. But in the northern end of the workings, several synclinal "rolls," clearly of fold origin, include both the talc rock and the schist.

Faults formed after steatitization are rather prominent in the Johnson talc body. The faults, in general, strike about north-northeast and dip predominantly 30° to 60° eastward; a few faults strike northwest and dip westward at moderate angles. There is no reliable evidence as to the direction and amount of movement along the faults, although strias and gouges generally indicate diagonal slip. Breccia zones up to 4 feet thick are developed along several of the faults. It is probable that the net slip of the faults is several tens to a few hundred feet. It has certainly been enough to complicate noticeably the structure of the deposit.

The serpentinite and grit are probably entirely of ultramafic origin. The steatite is believed to be derived dominantly from the ultramafic rock, but a small amount of the steatite, chiefly a thin layer next to the blackwall, has been formed by alteration of the blackwall. Locally, this alteration of blackwall to talc has been proportionately greater, so that steatite derived from blackwall makes up the greater part of the steatite zone. It should be emphasized, however, that this is a local feature and that, for the deposit as a whole, the larger part of the steatite zone is derived from the serpentinite.

The complexity of the Johnson deposit is due to a combination of several factors, the relative importance of which varies from place to place. These factors are: the complex and irregular shape of the original intrusive body, irregular steatitization of the schist, and folding, and faulting. It has not yet been demonstrated whether the folds involving the ultramafic body are forms impressed upon the intrusive body by previously folded rocks or whether at least part of the folding is post-intrusive.

Reserves.-- The operators make no attempt to evaluate reserves on the basis of "measured,"

"indicated," and "inferred" ore, chiefly because the character of the deposit and the methods of mining do not make such a practice economically feasible. Underground diamond drilling is practiced extensively at the Johnson mine, but has proved rather disappointing as a means of measuring reserves. The extreme irregularity of the deposit makes it impossible to form a quantitatively reliable estimate of reserves on the basis of diamond drilling alone.

The aim of the operators is at all times to have a 6 months reserve of ore in sight (about 20,000 to 25,000 tons). This amount constitutes the only "measured" reserve, but the geologic evidence suggests considerable "inferred" reserves of ore. It is probably a safe prediction that at least one or two years' supply of ore is left on the 200-foot level, and an unknown but considerable reserve on the 6th level, down to which the Mine No. 4 shaft has now been extended. A conservative conclusion is that there are probably sufficient reserves for at least 3 to 5 years more of operation at the present rate of production, or from 150,000 to 250,000 tons of ore. Further exploration may disclose much larger reserves. 13/

Locality 30

There is a small, abandoned talc mine near the southwest corner of the village limits of Johnson; the location is 0.75 mile S. 60° W. of the center of the village. The deposit is at an altitude about 640 feet above sea level and about 140 feet above the Lamoille River. Relief in the area is moderate, the maximum within a mile being about 800 feet.

To reach the locality from Johnson village, turn southwest off State Route 15 at the dummy policeman in the center of the village and drive for 0.5 mile to a fork in the road just beyond the railroad tracks. Take the right-hand fork and continue for about one-fourth of a mile to the mill of Eastern Magnesia Talc Co. The dump and a grove of small trees around the cave-in and open pit of the old workings are plainly visible in the open pasture about 500 feet south of the mill.

A railway shipping point on the St. Johnsbury and Lamoille County Railroad is only a quarter of a mile northeast of the locality.

The mine.-- The deposit was first mined in 1904, and small-scale operations were carried on more or less continuously until shortly after World War. 1. There are no accurate reports on the total extent of the workings but, judged by the durations of operations, the workings are probably rather extensive.

Geology.-- The country rock in the vicinity of the deposit consists of quartz-mica schist and blue-green, vitreous quartzite. Geological relations of the ultramafic body are poorly exposed in the badly slumped and caved open pit. The deposit appears to be similar to the Johnson mine deposit, being nearly or completely altered to grit and steatite. The grit exposed in the west wall of the cave-in is of good quality and superior color.

[13]Quoted with permission of Eastern Magnesia Talc Co., Burlington, Vt. Since the above was written, exploration and development about 150 feet below the 6th level have exposed large additional reserves of excellent talc.

The country rock strikes about N. 20° E. and dips steeply to the east. The steatite has a very well developed schistosity which is about parallel to that of the country rock. At the northeastern corner of the cave-in, the blackwall zone is discordant with the schistosity; presumably, this means that the ultramafic contact was also discordant at this point, although it was probably only a local feature.

The schists and quartzites show rather widespread folding on a small scale. In the schists, the folds are tight and have amplitudes measured in inches or one or two feet; in the quartzite beds, folds up to 10 feet in amplitude were observed.

Reserves.-- Knowledge of the size and nature of the deposit and of the extent to which it was worked in the past is meager. Consequently, it is difficult to arrive at any valid estimate of reserves. It is probable, however, that reserves of recoverable material are small.

Barnes Hill talc prospect, Locality 40

The Barnes Hill talc prospect is in the northeastern part of Waterbury township, about 2.2 miles N. 35° E. of the road triangle at Waterbury Center. The deposit lies at an altitude of about 1180 feet on a gently rolling upland of low relief.

To get to the prospect from Waterbury village, take State Route 100 northeastward from Waterbury for a distance of 3.5 miles from the junction with U. S. Route 2. Turn right (east) off Route 100 and continue east for 0.35 miles to the eastern corner of the road triangle, a few hundred feet beyond the traffic light. Turn left (northward) and continue northeastward along the main graveled road for 2 miles. The talc deposit lies about 1000 feet east of the road at this point on the crest of a low ridge.

The deposit is in open country and is of easy access. The nearest railroad is at Waterbury village, about 6 miles to the southwest.

Wigglesworth (1916, pp. 284-286) has studied and described briefly the locality.

The prospect.-- Limited prospecting has been carried out at the Barnes Hill locality at several times in the past. A small prospect shaft, reportedly about 15 feet deep, was sunk near the center of the east side of the deposit, and a number of small pits and trenches were opened. In 1947 the Eastern Magnesia Talc Co. drilled six diamond-drill holes, which total about 1300 feet in length, along the east side of the deposit.

Geology.-- The ultramafic body is crudely elliptical in plan and has a known length of about 1400 feet and a maximum width of 375 feet. The trend of the long axis is about N. 20° E. At the northern end the western contact strikes somewhat east of north and dips steeply to moderately eastward; at the southern end the western contact strikes northwest to west-northwest and dips moderately northward. The attitude of the eastern contact is not known, but judging from the schistosity of several outcrops of schist to the east of the ultramafic body, probably it also dips steeply eastward.

The deposit consists almost entirely of grit and serpentinite, but locally within the ultramafic body there are thin tabular masses of carbonate rock. Possibly these are septa or inclusions of sedimentary carbonate, or they may be segregations formed during the steatitization process. The greatest concen- northern end of the deposit. However, the spatial relation between the serpentinite and grit is not as simple as that found in most lenticular deposits, for grit occurs sporadically in the serpentinite throughout the width of the deposit. Apparently, the transition from grit to serpentinite is nearly always very abrupt, taking place in a fraction of an inch. However, petrographic study may disclose that the transition is not so abrupt as the megascopic appearance seems to indicate.

A fine banding is readily distinguishable in the majority of serpentinite outcrops and more faintly preserved in many of the grit outcrops. The banding is emphasized on weathered surfaces. Megascopically, the banding appears to consist of alternating dark and light layers one-sixteenth to one-fourth of an inch thick. Microscopically, banding in the two sections examined consists of alternating layers of serpentine and carbonate. The banding commonly has a fairly uniform attitude within the limits of a small outcrop, but from outcrop to outcrop the attitude is variable, ranging from strike north to east, dip moderate to steep either side of vertical. The average strike of the banding at the north end of the body is about north to northwest, the average dip probably steep to the east; at the south end the average strike is more nearly east, the dip moderately to steep northward. Thus, in a general way, the average attitude of the banding appears to reflect the attitude of the nearby contact between ultramafic rock and country rock. The origin of the banding is, as yet not established. It is possibly primary, possibly a later shear feature.

The country rock is quartz-mica schist, graphitic phyllite, and fine-grained chlorite amphibolite; the schist and phyllite contain garnet and biotite. The blackwall is nowhere well exposed; so, its mineralogy is not known.

The average strike of the schist is about N. 20° E. and the general dip is steep to the east. Around the margins of the ultramafic body the strike and dip of the country rock range sympathetically with that of the contact; thus, at the southwestern end of the body the amphibolite strikes far into the northwest and dips moderately to the northeast in conformity with the contact of the ultramafic body with the amphibolite. Small folds in the amphibolite plunge 25° to 50° northward.

Reserves.-- Reserves are almost certainly large. It is possible, however, that the irregular alteration of the serpentinite to grit, resulting in numerous inclusions of serpentinite within the grit bodies, will cause difficulties in mining that will seriously reduce the tonnage of recoverable material. This factor cannot be evaluated nor a quantitative estimate of reserves be made until contemplated further diamond drilling operations are carried out.

Waterbury talc mine, Locality 41

The Waterbury talc mine, the second largest in Vermont, is in northwestern Moretown township on the south bank of the Winooski River, 2 miles S. 45° E. of the junction in Waterbury village of State Route 100 and U. S. Route 2. The area is one of moderately high relief, the maximum within a mile of the mine being more than 1200 feet. The altitude of the millsite at the north end of the ultramafic body is about 470 feet; the southern end of the body attains an altitude of at least 1300 feet.

The mine can be reached from Waterbury village by driving southeastward from the junction of State Route 100 and U. S. Route 2 for 2 miles on U. S. Route 2; turn right (south) into the driveway of Eastern Magnesia Talc Co. Mill No. 2. The mine entrance is at the south end of the mill.

The central Vermont Railroad at Waterbury village, about 2 miles northwest, is the nearest railway shipping point.

Gillson (1927, pp. 271-274) discusses the petrology and origin of the Waterbury deposit.

The mine.-- There are three levels in the Waterbury mine-- the Tramway level, the 1st (or Adit) level, and the 2d level. The Tramway level, which has been abandoned for many years, has an adit entrance at an altitude of 680 feet above sea level. The level is about 700 feet in total length, but only the first 100 feet are accessible. The 2d level, which is reached by a raise from the 1st level, is at an altitude of 712 feet. The workings total about 900 feet, but only 250 feet are accessible. The 1st level, the only one now being mined, is at an altitude of 520 feet at the adit entrance and contains about 5000 feet of workings. The combined workings of all the levels total approximately 6500 feet.

Mining operations are on a small scale, and mining methods are simple but efficient. In general, drifts are driven in steatite or grit, and heavy timbering is necessary throughout almost the entire length of the mine. The broken rock at the working face is loaded into 1-ton mine cars by pneumatic mucker. A self-caving method of stoping is employed where possible; where self-caving methods are not feasible, inclines are driven in the steatite and grit along the hanging-wall and the talc is mined by benching. The ore is trammed by battery locomotive to the mill where it is sorted and dumped into several bins according to grade. Pencil stock is sorted by hand.

Geology.-- The main ultramafic body has a minimum length of 4500 feet and a maximum width of 550 feet. The general strike of the deposit is N. 10° to 15° E. Along the strike, both on the surface and in the underground workings, the body pinches and swells from a minimum thickness of 1 foot underground and 30 to 40 feet at the surface to a maximum of 150 feet underground and 550 feet at the surface. In cross-section, the body at its simplest is crudely

V-shaped or Y-shaped. The southern half of the deposit has, however, been complicated by folding of the eastern contact, which shows up in the 2d level as a fold over 80 feet across, and on the surface as a fold probably several hundred feet across. It is this feature which is responsible for the great width of the serpentinite body at the surface as contrasted with its underground at the south end of the deposit. The average attitude of the deposit is vertical or steep to the east. Both walls, on the average, dip steeply inward, although there are numerous local reversals of this attitude.

About 500 feet east of the main ultramafic body is a narrow body of steatite, grit, and serpentinite. The maximum width of the deposit at the surface is 80 feet, the average width probably under 10 feet. The probable length is at least 4000 feet. The attitude of the deposit is about the same as that of the main body. This deposit is not developed to any extent and its relations to the wall rock and to the main ultramafic body are not well known.

The country rock in the immediate vicinity of the ultramafic bodies consists entirely of quartz-mica schist and albite-quartz-mica schist. A thousand feet or so to the west, however, greenstones are numerous.

The general relations within the ultramafic body, which hold everywhere except in the narrow places in the body where the serpentinite core is absent or where late faulting has disturbed the normal relationship, are as follows: The center of the ultramafic body is serpentinite varying from less than a foot to more than 500 feet thick. A zone of grit from less than 1 foot to 20 feet thick borders the serpentinite core. Outside the grit zone is a zone of steatite reaching a maximum thickness of 6 feet and generally less than 1 foot. The average width of the combined talc and grit zones is between 5 and 10 feet. The blackwall zone, on the average, is between half a foot and 1 foot thick.

The ultramafic bodies are in most places concordant with the enclosing schists, which strike on the average about N. 10° to 15° E. and are vertical or dip steeply east or west. Locally, however, the ultramafic bodies are cross-cutting. This cross-cutting relationship is best exposed in the underground workings, where detailed mapping shows that (tracing the deposit southward) the concordant relationship holds for distances of several hundred feet, whereupon the ultramafic body becomes cross-cutting slightly for a short distance so that it is offset to the west a few inches or a few feet. In one or two places the offsetting is apparently due to minor folds rather than to discordance. Practically all of these locations are marked by long, thin septa of schist projecting into the talc body; they were apparently peeled off the schist wall during the late-stage faulting, tongues of talc being forced into the resulting spaces between the septa and the main schist body.

Near the southern end of the underground workings, the ultramafic body is cut by a mafic dike which appears to have been intruded after steatitization. A fault about parallel to the western contact of the ultramafic body cuts the mafic dike which is nearly vertical, and offsets it about 135 feet horizontally, the east side having moved north. Slickensides and deep grooves on the fault surface plunge 30° to 40° to the northeast; so the net slip on the fault has probably been of the order of 175 feet.

The eastern body probably is entirely separate from the main body. Possibly, however, both deposits are part of a tightly folded, originally sheetlike mass, with the main body on the western limb and the eastern body on the eastern limb of an anticline plunging to the north, the nose of the anticline plunging beneath the schists somewhere between the mill and the Winooski River.

Reserves. -- The practice of evaluating reserves at the Waterbury mine is the same as at the Johnson mine. "Measured" ore totals about 10,000 to 20,000 tons, or 6 months supply. "Indicated" and "inferred" ore, on the basis of geologic evidence and past mining experience, is believed to be adequate for at least 5 years, or at least 150,000 to 200,000 tons.

Mad River talc mine, Locality 46

A large ultramafic body is exposed in the southeastern part of Duxbury and the northeastern part of Fayston townships. The Mad River talc mine is in the southern end of the body, and there are two abandoned verde antique quarries at the northern end. Possibly localities 33 and 47 are continuations of this body.

The Mad River mine at the southern end of the deposit, is 2 miles S. 63° W. of the center of the village of Moretown. The mine lies at an altitude of about 950 feet. Relief in the immediate area is moderate; the maximum within a mile of the mine is about 1300 feet.

To reach the mine from Moretown, drive south on State Route 100 for a distance of 0.45 mile beyond the junction with Route 100 B, which is about a mile south of the village. Turn right (west) on a dirt road at this point and continue westward for about 1.1 miles to the mine.

The nearest railway shipping point is at Middlesex village on the Central Vermont Railroad, about 7 miles to the northeast.

Bain (1936, pp. 1971-1972; fig. 4) gives a brief general discussion of the Mad River ultramafic body; Gillson (1927, pp. 268-271) discusses the petrology and origin.

The mine. -- The Mad River deposit has been mined at several times over a period of many years. The operations have been carried out by different companies and the mine known by several names. The last organization to engage in mining operations was the Mad River Talc Corp., under whose management the mine was known as the Mad River talc mine. The mine has been idle since 1946.

There are five so-called levels or groups of workings in the mine. For convenience these have been designated as the 890-, 900-, 907-, 930-, and 968-foot levels; the numbers refer to the altitudes of

the floors of the levels above sea level. The total length of the underground workings, is about 1000 feet. Of this total, the southern 160 feet of the 907-foot level was flooded and inaccessible in 1945 at the time of mapping.

The 890- and 900-foot levels were worked by a shaft inclined an average of 46° to the north and approximately 115 feet deep, measured along the incline. The 907-foot level is accessible through a small opening from the west side of the inclined shaft, but mining operations on that level appear to have been carried out from a short vertical shaft known as "Skunk Shaft." located 110 feet S. 20° W. of the collar of the incline. The 968-foot level has an adit entrance in the northeastern corner of the open pit. The 930-foot level is now accessible only through a winze located about the middle of the east side of the 968-foot level. It is probable, however, that a raise from the 890-foot level once connected it and the 930-foot level, and that the ore was carried out through the 890-foot level; if so, this raise is now inaccessible because of caving.

Mining operations were carried out, apparently, by drifting and caving, and were entirely by hand. The material was moved probably by wheel barrow to the foot of the incline where it was dumped into a skip and hoisted to the surface. There the ore was dumped into small cars and hand trammed to the mill.

Geology. -- The ultramafic body has a known length of about 4500 feet and a maximum width of 800 feet at the north end, narrowing down to less than 50 feet at the south end. If the serpentinite and grit at localities 33 and 47 are part of this same body, the total length of the deposit is more than 10,000 feet. The general trend of the body is about N. 25° E. The contacts dip steeply either side of vertical; in the open-cut and cave-in at the talc mine, the contacts dip steeply inward.

Considered as a whole, the ultramafic body is composed almost entirely of serpentinite; the only known talc is at the north and the south ends of the deposit. It is probable, however, that a thin zone of steatite and grit exist along the contacts throughout the length of the body. No unaltered peridotite masses have been found, but detailed petrographic studies have not yet been made. Bain (1936, pp. 1971-1972) describes relics and ghosts of olivine and pyroxene from this locality.

The steatite and grit zones as exposed in the underground workings of the mine vary in total width from 2 to 10 feet, the steatite zone occupying 0.5 to 3 feet of the total. Steatite and grit occupy the entire width of the deposit in the open pit immediately north of the mill, where the body narrows down to less than 25 feet wide. Tremolite is abundant locally, especially along the eastern contact in the outer part of the steatite zone, and occurs sporadically throughout the zone. In a few places, tremolite is so abundant that the rock is essentially a tremolite rock with minor talc and /or carbonate.

Several eastward-trending, nearly vertical mafic dikes cut the ultramafic body and the country rock. The dikes probably are later than the steatization. Small faults or shear zones are prominent along both edges of the body, and to a lesser extent, within the serpentinite core. The offset along these shears has displaced the mafic dikes considerably, but it cannot be accurately determined.

The country rock is phyllite, quartz-mica schist, and greenstone. All of these are altered to chlorite at the contact with the steatite. In general the ultramafic body is concordant with the schistosity and bedding of the schists, although the relations locally are cross-cutting.

A number of small outcrops of serpentinite, grit, and steatite are exposed between 200 and 350 feet east of the eastern contact of the main ultramafic body, and within or at the western border of a greenstone bed about 80 feet thick. Probably these outcrops are on a series of discontinuous, lenticular bodies rather than on a single, long, narrow body. The grit and steatite are generally rather dark and impure. Most of the outcrops have been prospected for talc by trenching, probably many years ago.

Reserves. -- Reserves are probably small, the greater part of the easily accessible talc having been mined out. The best chance for locating sizable reserves lies in exploration at greater depths and in explorations southward from the old workings and at the north end of the body. Such exploration would have to be by diamond drilling, supplemented in a few favorable places by trenching, or by geophysical methods, or both, for outcrops are almost entirely absent in the critical areas.

Locality 50

There is an ultramafic body in central Warren township on the farm of L. W. Freeman, 0.25 mile due east of the church in Warren village. The deposit lies at an altitude of about 960 feet at the foot of the south-western slope of Warren Pinnacle, a 1700-foot hill north-east of Warren village.

To get to the locality from Warren village, drive northeast from the church on the road along the left (south) bank of Freeman Brook for 0.1 mile and turn right. Continue southeast for 0.2 mile to a fork in the road and take the left-hand fork. The farm house on the land where the deposit is located is about 100 feet beyond the fork, on the left (north) side of the road. The southern end of the outcrop of serpentinite is 200 feet due south of the house.

The nearest railroad is the Central Vermont at Roxbury village, about 7 miles eastward over Roxbury Gap, which is at an altitude of 2416 feet.

Geology. -- The size and shape of the body are indeterminate, because the country rock is exposed only at the southeastern edge of the outcrop area. The serpentinite forms essentially one large, continuous outcrop nearly 500 feet long and more than 200 feet wide, and is roughly elliptical. The long axis of the outcrop, which is probably parallel to the long axis of the deposit, trends about N. 15° E., or about parallel to the strike of the schistosity in the region.

The country rock schist is exposed in only two small outcrops near the ultramafic body. The schist strikes N. 15° E. and dips 60° to 70° eastward.

The deposit is chiefly serpentinite. Locally, especially on the southern nose of the outcrop, relatively large patches of rock are somewhat talcose. The contacts with the schist are nowhere exposed, nor are there any exposures of steatite or grit to indicate the probable location of the contacts. Although this lack of exposures of steatite and grit may be taken as an indication that talc is not extensively present here, a Mr. Freeman of Warren (oral communication, September 1948) stated that soapstone reportedly was sawed at this locality for freestones approximately 100 years ago.

Reserves. -- Although the evidence is inconclusive, there are no positive indications that steatite and grit are extensive at this locality.

Locality 51

A small ultramafic body is exposed 0.75 mile N. 24° E. of the four corners in East Warren village. The outcrop is approximately 100 feet west of U. S. Geological Survey bench mark 1371. The deposit lies at an altitude of 1380 feet near the crest of a low hill on a gently rolling upland surface with a relief of little more than 100 feet.

To reach the locality from Warren village, drive northeast from the church on the road along the left (south) bank of Freeman Brook for 0.1 mile and turn right. Continue southeast for 0.2 mile to a fork in the road and take the right-hand fork. One and one-half miles beyond the fork, turn left (north) and continue northward 0.75 mile beyond the four corners at East Warren, to a point opposite B. M. 1371. The ultramafic body is situated about 200 feet west of the road near a line fence.

The nearest railroad is the Central Vermont at Roxbury village 5 miles to the east and across the Northfield Mountains by way of Roxbury Gap (altitude 2416 feet); or at Middlesex, about 15 miles to the northeast down the valley of the Mad River.

Geology.-- The outcrop area of the deposit is less than 100 feet long (north-south) and 50 feet wide. The deposit may extend under cover for a considerable distance to the north and to the south.

The serpentinite is dark green, fine-grained, and rather highly fractured. The country rock nearby is a peculiar whitish-green rock, apparently a highly altered greenstone. More or less "normal" greenstone occurs locally within the whitish-green rock. Quartz-mica schist, somewhat graphitic, crops out 500 feet northwest of the serpentinite. The schist strikes about N. 15° to 20° E. and dips 70° to the east.

The relationship of the tremolite-chlorite rock to the serpentinite suggests that the greenstone formed the roof of an ultramafic body only a small part of which has been exposed by erosion, and that the alteration of the greenstone is related to steatitization, although evidence of extensive steatitization is lacking.

Reserves.-- No outcrops of steatite or grit were found. Consequently, it is considered probable that the serpentinite has not been extensively steatitized, and that the potentialities of the deposit as a talc producer are small.

Locality 54

There is a small abandoned talc quarry in southern Roxbury township, 1.35 miles N. 2° W. of the railroad bridge at East Granville over the Third Branch of the White River. The deposit is located 40 feet west of State Route 12 A and 330 feet north of the boundary between Addison and Washington Counties. Its altitude is 900 feet and it is about 40 feet above the river. Relief in the area is moderately high.

To reach it from East Granville, drive northward on State Route 12 A about 1¼ miles from the center of the village to the sign marking the boundary between Addison County and Washington County. Continue northward 330 feet beyond the sign. The old quarry, completely invisible from the road because of heavy underbrush, is 40 feet west of this point.

The Central Vermont Railroad is a few hundred feet east of the quarry.

Geology. -- The deposit has been completely mined out to a depth of at least 30 feet, and the quarry is now partly filled with water. There are no exposures except in the quarry walls, which are so difficult of access that a close examination could not be made.

The quarry is oval in plan, with a maximum length of 200 feet and a maximum width of 75 feet. The full width of the body has been quarried, and no serpentinite was found on the dump; presumably the entire deposit was composed of grit and steatite. Material collected from the dump indicates that at least some of the talc was of fairly good quality.

The contacts dip inward about 75 degrees on both sides of the quarry. The country rock exposed in the walls is chlorite-quartz-sericite schist, altered to chlorite (the blackwall) for a width of 0.5 to 1 foot at the contact with the ultramafic rock.

Reserves. -- It appears that all of the easily accessible ore has been mined. Probably only a small reserve is left below the quarry floor, unless the inward dip of the walls reverses at moderate depth.

Roxbury verde antique quarries, Localities 66 and 67

Half a mile or so west of Roxbury village is the center of a north-trending belt of numerous ultramafic deposits (localities 55-71), several of which have been quarried for verde antique. Two of the bodies have been examined briefly.

Locality 67, which is now being quarried for verde antique by the Vermont Marble Co., is 1.1 miles S. 25° W. of the four-corners in Roxbury village. Locality 66, an abandoned verde antique quarry, is about 200 feet northwest of locality 67. Both deposits lie at an elevation of about 1150 feet, on the crest of an oval-shaped hill some 150 feet high.

The Central Vermont Railroad runs along the base of the precipitous southeastern face of the hill.

Access from Roxbury village is as follows: Drive south on State Route 12 A a distance of 0.7 mile from the four corners. (Note: the right of way of Route 12 A has been changed since the Barre quadrangle map was issued, and the road is on the east side of the railroad for the entire distance between Roxbury village and Roxbury Flat, rather than as shown on the topographic map.) Turn right across the railroad and drive west for 0.2 mile; turn left and continue for about 0.3 mile to the end of the road. The quarry at locality 67 is immediately to the left.

Phillips and Hess (1936, pp. 349-351; fig. 8) describe and figure the ultramafic body at locality 66.

Geology. -- Both ultramafic bodies are lenticular or pod-like, elongate a little east of north, and are about vertical. Both have a central core of serpentinite surrounded by a thin shell of steatite. Locally, the serpentinite core is irregularly altered to highly serpentinous grit.

The country rock is greenstone and quartz-chlorite-sericite schist. At the contact with the ultramafic rock the country rock is altered to chlorite. At these two localities only the greenstone has been observed in contact with the ultramafic rock.

The ultramafic body at locality 66 is about 200 feet long by 75 feet wide, and has reportedly been mined to a depth of more than 150 feet, where the serpentinite core bottomed in grit. The quarry is now filled with water.

The ultramafic body at locality 67 is possibly continuous with an outcrop of grit in the railroad cut and with one in the road cut on Route 12 A due south of the quarry. The deposit, then, is perhaps nearly half a mile long and more than 100 feet wide. It has been mined to a depth of more than 200 feet, and the quarry floor is still in verde antique of good quality.

Reserves. -- Having made only a cursory examination of a small part of the area, we have little basis for evaluating the potentialities of the deposits as talc producers. We believe, however, in the possibility of fairly large reserves of good quality talc, particularly in the southern extension of locality 67.

East Granville talc mine, Locality 72

The East Granville mine, reportedly the largest mine in the state during its period of operation, but long since abandoned, was operated for several years on a talc deposit in northeastern Granville township. The mine site is 0.3 mile due east of the center of the village of East Granville, and just a few hundred feet west of the eastern border of Granville township. The deposit is at an altitude of 1150 feet on the steep western slope of a north trending ridge and on the east side of Third Branch of the White River.

To reach the locality from the center of East Granville, drive southward on State Route 12 A for 1.3 miles. (Note: the right of way of 12 A has been changed since publication of the Lincoln Mountain, Randolph, and Barre quadrangles; the road is now on the west side of the Central Vermont Railroad for the entire distance between East Granville and Braintree.) Turn left 150 degrees onto the old right of way of Route 12 A, cross the railroad tracks, and continue northward for about 0.3 mile; turn right over the bridge across Third Branch of the White River. Continue northward for about half a mile; then, immediately after crossing a small creek, turn left on an old wood road into a small pasture. Park here and continue northward on foot along the wood road. A few hundred feet from the small pasture, near the top of the first steep pitch in the trail, take the left-hand fork and continue about half a mile to the mine.

The Central Vermont Railroad at the village of East Granville is only 0.3 mile west of the mine.

Geology. -- In the few hours spent at this locality, we examined only two of several cave-ins. So we know little of the size and shape of the deposit. The location of the old underground workings is marked by a series of half a dozen or more cave-ins. The individual cave-ins are nearly or quite concordant with the schistosity of the country rock, but as a group they are in echelon.

About 300 feet northeast of the old waste dump is a cave-in about 100 by 50 feet in plan. Highly schistose grit, steatite, blackwall, and chlorite-quartz-sericite schist are exposed in the north wall. The relations, however, are different from those encountered in most of the other deposits examined. The grit is coarsely flaky with a strong but wavy schistosity, buff-colored, and contains scattered knots, streaks, and folia of chlorite and irregular nodules of carbonate. The steatite is rather high in chlorite which is somewhat patchily distributed and has good schistosity.

Some of the grit grades directly into blackwall and has obsiously been derived from it, and it is possible to trace relic bedding and schistosity from the schist through the blackwall into the grit. Elsewhere, grit grades into steatite in the usual manner. All of the grit is identical in appearance. Because some has obviously been formed by alteration of the country rock, and because that which is definitely of such origin appears no different from the rest, there is no compelling evidence that any of the talc rock exposed is of ultramafic origin. The exposures of this cave-in may not, however, be typical of the deposit as a whole. Probably they represent a striking but local alteration of the country rock to talc, whereas the deposit as a whole is of ultramafic origin. Detailed study of the area and examination of material on the dump for evidence of what was encountered in the mine should provide an answer.

The country rock is quartz-chlorite-sericite schist. The schistosity and bedding are parallel, strike slightly west of north, and dip steeply east or vertical.

Reserves.-- Probably most of the accessible talc has been mined.

Rochester verde antique quarry, Locality 73

There is a large abandoned verde antique quarry

in northern Rochester township, 2.95 miles due north of the square in the village of Rochester. The deposit lies about 1480 feet above sea level and near the southwestern edge of a small upland flat between the Braintree Mountains and a range of high hills along the east bank of the White River.

To reach the locality from Rochester village, drive north from the square in the center of the village for about 2 miles on State Route 100. Turn right on the North Hollow road and drive 0.55 mile to a fork in the road. Take the left-hand fork and continue 1 mile to the quarry, which is on the left (northwest) side of the road. Large grout piles on either side of the road mark the location.

The nearest railway is the Central Vermont at Randolph village, about 15 miles eastward by road across Rochester Gap, which is at an altitude of 2100 feet. There is also a railway at Bethel, 20 miles southeastward by road along the valley of the White River.

Gillson (1927, pp. 266-268) discusses the petrology and origin of the Rochester quarry under the title of "The Verde Antique Quarry at North Hollow."

Geology.-- The only exposures noted are those due to quarrying operations which are confined almost entirely to the ultramafic body. So, the size and shape of the ultramafic body are not known. The quarry, however, is about 300 feet long and 150 to 200 feet wide; its depth is not known because the quarry is now filled with water. Most of the rock exposed in the quarry walls is serpentinite. In the northeastern corner of the quarry, a concordant contact between the ultramafic body and schist is exposed for a distance of 10 to 15 feet. The contact strikes east and dips 85° to the south, whereas the regional trend of the schistosity in the area is about N. 10° W., dip steep to the east. The schist exposed at the contact, then, has a strongly abnormal attitude. It may be only a septum within the ultramafic body and not the true wall.

Grit and steatite for a width of 3 or 4 feet are exposed next to the contact. The grit-serpentinite boundary is irregular and gradational over a width of several inches. The schist has been altered to chlorite (blackwall) at the contact with the steatite for a width of approximately 1 foot. The blackwall is gradational into unaltered schist over a width of 1 or 2 inches. Between the blackwall and the steatite is a 3 to 5 inch zone composed almost entirely of actinolite in rosettes from 1 to 3 inches across.

A few hundred feet south of the quarry and on the opposite side of the road, bulldozing operations performed in the spring of 1948 exposed a narrow southern continuation of the ultramafic body. The exposure is about 20 feet wide and 120 feet long. The maximum width of grit exposed is about 15 feet. Bordering the grit, which is rather impure and contains rather abundant serpentine, is a thin zone of steatite, which is bordered in turn by a foot of actinolite. That, in turn, is bordered by 1 foot of blackwall chlorite which grades into unaltered greenstone. The schistosity of the greenstone in the southern and central part of the exposure is N. 30° E., dip 60° eastward; at the northern end of the exposure the schistosity strikes northwest and dips 50° to 70° northeast. A well developed schistosity in the grit and steatite has a uniform attitude of strike north, dip about 35° to the east.

Reserves.-- It does not appear, on the basis of a brief examination of the locality, that the ultramafic body is extensively steatized.

Localities 74 and 75

Several ultramafic bodies are reported in southeastern Rochester township. Two of these, the old Williams mine deposit and the Cushman Hill deposit, were examined and will be described briefly below.

The Williams mine, at locality 74, is 2.65 miles S. 70° E. of the square in the center of Rochester village. The mine was one of the larger in Vermont prior to 1927, when it was abandoned because of a destructive flood that washed out part of the White River Railroad tracks. The deposit is located on the west flank of the Braintree Mountains at an altitude of 2040 feet.

The Cushman Hill deposit, locality 75, lies half a mile N. 30° W. of the Williams mine and crops out over the entire hill above the altitude of approximately 1940 feet.

Relief in the immediate vicinity of the deposits is low; within a radius of a mile of the mine, total relief is about 1600 feet.

The locality is most readily accessible from Rochester village. Drive eastward along the north side of the village square to a fork in the road 0.1 mile beyond the square. Take the right-hand fork and continue eastward for about 1.2 miles to the four corners. Turn right (south) and continue southwestward for 1.3 miles to the South Hollow School. At the school house take the left fork and drive southeastward for 0.3 mile. Cushman Hill lies about a quarter of a mile due north of this point. About 900 feet N. 45° E. of this point on the road is an old talc prospect, marked by a small dump and the foundation of an old building.

To reach the Williams mine, follow the same route from Rochester village but continue on to a point 0.6 mile beyond the South Hollow School. The site of the old mine is 600 feet to the east.

The nearest railway shipping point is at Bethel on the Central Vermont Railroad, about 20 miles southeastward by road down the valley of the White River.

These localities have been described briefly by Jacobs (1914, pp. 410-412), and Gillson (1927, pp. 262-266).

Geology. -- In the vicinity of the Williams mine serpentinite, grit, and steatite crop out intermittently in a narrow, north-trending belt more than 1000 feet long.

The size and shape of the deposit is not known. All the outcrops may be of a single body, or they may represent exposures of several separate lenses.

Several of the steatite outcrops exhibit a good schistosity having the same general attitude as that of the schists. The country rock is quartz-mica schist, greenstone, and amphibolite. The schistosity strikes N. 20° to 50° E. and dips 45° to 85° to the northwest. Abrupt changes in the attitude of the schistosity and bedding (which are locally divergent in attitude) and numerous minor folds observed in outcrop suggest that folding may be of considerable importance in determining the form and distribution of talc at this locality.

Cushman Hill, half a mile northwestward from the Williams mine, is upheld by a large serpentinite mass, which is well exposed on the upper slopes and the crest of the hill. Grit crops out in the shallow saddle about 260 feet east of the eastern limit of serpentinite outcrop, or about 450 feet N. 18° W., of the waste dump. An old shaft, a small dump, and several caved areas indicate that talc has been mined in the past on a small scale, but give no conclusive evidence on the extent of the talc deposit. The grit exposed in outcrop and that upon which the mining was done are possibly marginal to the serpentinite exposed on Cushman Hill. If so, the grit-steatite zone may be as much as 260 feet wide.

The contact of the ultramafic body was not observed, but quartz-mica schist is extensively exposed on the southern slope of Cushman Hill near its base. The strike of the schist averages about N. 60° W., ranging between N. 5° E. and N. 75° W.; the dip is gentle to moderate to the northwest. Numerous folds as much as 10 feet in amplitude and 20 to 30 feet across are exposed in outcrop. The folds plunge 20° to 40° to the north and northwest.

Reserves. -- Reportedly the Williams mine was abandoned because a flood destroyed the railroad to Rochester, rather than because the supply of talc was exhausted. The old workings, now caved and in disrepair, probably would constitute a serious obstacle to reopening the deposit.

Although exposures at Cushman Hill are lacking in critical areas, the relations noted in the reconnaissance of the area suggest the possibility that large reserves of talc exist on the eastern edge of the large serpentinite body.

Locality 110

A small ultramafic body crops out in northeastern Ludlow township, 0.8 mile S. 22° E. of the North Hill School, and 3 miles N. 25° E. of the Road bridge over the Black River in Ludlow village. The deposit lies at an altitude of 1500 feet in an area of low relief.

To reach the locality from Proctorsville, drive northward on the graveled road at the east edge of the village for 3 miles after leaving State Route 131. Take the left fork at this point and continue 0.5 mile to another fork in the road. Take the right fork and drive northwest for 0.75 mile. The ultramafic body is about 400 feet west of this point, in a small open wood.

The nearest railway is the Rutland, about 3 miles southeastward at Ludlow village.

Geology. -- The deposit is exposed for about 100 feet along the strike. At the southern end of the exposure, the width of the ultramafic body is 5 to 10 feet; at the northern end, the deposit widens to 30 or 40 feet. The deposit strikes about N. 15° E. and appears to be essentially vertical.

Structurally below (west of) the ultramafic body, the country rock is dark green amphibolite, which grades upward into ankeritic amphibolite. This, in turn, grades into a chlorite-carbonate greenstone, which grades through a chlorite-talc rock into a poor grade of grit, low in carbonate but dark in color, apparently owing to the presence of abundant chlorite. Above the grit lies quartz-sericite-chlorite schist; the transition between the grit and the overlying schist is sharp.

Reserves. -- On the basis of a perfunctory examination, this deposit does not appear to be of mineable quality or size.

Localities 112 and 113

Two small talc and grit bodies, both of which were mined on a small scale many years ago and which were known as the Valentine Mines No. 1 and No. 2, are located in east-central Ludlow township. Valentine No. 1 is 0.9 mile N. 85° E. of the road bridge over the Black River in Ludlow village. Valentine No. 2 is 0.85 mile N. 70° E. of the road bridge. Mine No. 1 lies at an altitude of 1140 feet above sea level; No. 2 at an altitude of about 1260 feet. Total relief within a mile of the mines is about 500 feet.

From Proctorsville, drive westward on State Route 103 for 2.5 miles from the junction of State Routes 103 and 131. Turn right on the dirt road and continue north for 0.3 mile. The water-filled shaft of old Mine No. 1 is about 50 feet east of the road at this point. To reach the Valentine No. 2, drive 0.1 mile north beyond the location of Mine No. 1 and walk westward along the power line for a distance of about 500 feet from the road. The open cut of the old mine is about 100 feet north of the power line at this point, on the east side of a small south-trending ridge.

The Rutland Railroad is only about a mile westward, at Ludlow village.

Geology. -- Both deposits are narrow, tabular or lenticular bodies between 10 and 20 feet wide; they strike nearly north and dip steeply east. The relations at Mine No. 1 are obscured by slumping. The central part of the Mine No. 2 deposit is grit, with a narrow steatite border. The country rock of both deposits is quartz-sericite-chlorite schist, altered to chlorite at the contact with the steatite.

Reserves. -- Both deposits appear to be very small and to be more or less completely mined out.

Locality 114

In east-central Ludlow township, 1 mile S. 57° E. of the road bridge over the Black River in Ludlow village is an old abandoned talc quarry. The deposit lies at an elevation of 1000 feet, about 200 feet south of the Rutland Railroad and at the foot of the north slope of a steep hill. Total relief within a mile is about 500 feet.

The locality is easily accessible. From Proctorsville, drive westward on State Route 103 for 2.4 miles from the junction of State Routes 103 and 131. Turn left across the Black River for about 0.3 mile to a point just south of the railway and take the left-hand fork. A hundred feet or so beyond the fork, turn left onto a wagon road through a small meadow. The old quarry is at the north edge of the meadow.

Geology. -- The quarry is about 125 feet long north-south and 75 feet wide. The quarry is filled with water; so, the depth is unknown. Only grit of excellent quality is exposed. The country rock which is exposed 100 feet east of the quarry in a small gully is quartz-chlorite-sericite schist.

Reserves. -- A thick cover of glacial drift blankets the deposit, but the fact that the entire quarry is in grit of good quality indicates the possibility that the deposit is large.

Hammondsville talc quarry, Locality 117

The Hammondsville talc quarry is located in eastern Reading, 0.2 mile northeast of U. S. Geological Survey B. M. 969 in the village of Hammondsville. The deposit lies at an altitude of 1000 feet above sea level at the foot of the west slope of Wardner Hill. Relief in the immediate area is moderate; total relief within a mile of the quarry is about 1000 feet.

The deposit is readily accessible by auto. From Proctorsville, drive eastward on State Route 131 about 7.8 miles to the junction with State Route 106; turn left (north) on 106 and continue about 7¼ miles to a point 0.15 miles beyond Hammondsville. The talc quarry is 200 feet east of this point on the road.

The nearest railway is the Rutland at Proctorsville, about 14 miles by road to the southwest.

The quarry.-- The quarry, in 1945, was 200 feet long and 125 feet wide; the greatest depth, which was at the southern end, was 45 feet. Operations are entirely mechanized; overburden is removed by bulldozer, the rock is broken by pneumatic drilling and by blasting, and the ore loaded by gasoline shovel into trucks. The ore is hauled by truck to the mill at Chester, about 15 miles to the south. Only the coarse rock is saved, the "wet fines being discarded because the mill is not equipped to dry the material before grinding."

Geology. -- The full extent of the deposit is not known. As exposed in the vicinity of the quarry, the deposit is at least 450 feet long, 150 feet in outcrop width, and 90 to 100 feet thick.

The contact between the steatite and schist is concordant with the foliation and bedding of the schist and varies from strike north, dip 40° to 50° east at the southeastern end of the quarry to strike northwest, dip 25° to 30° northeast at the northwestern end of the quarry. Thus the talc deposit and the country rock are involved in a broad anticlinal arch. Minor folds plunge 15° to 30° to the north or slightly east of north.

The deposit consists entirely of coarse, flaky grit and of steatite; no serpentinite has been found. In the southwestern face of the quarry there is a large mass of actinolite rock. Near the top of the southeastern quarry face there are several thin but extensive septa of schist which are largely altered to coarse biotite and chlorite.

The country rock is quartz-mica schist. Next to the talc body the schist is altered to blackwall, which is coarse biotite for about the first half a foot and grades abruptly into chlorite for about an equal thickness. The blackwall grades over a short distance into unaltered schist.

Both the steatite and grit have a very good schistosity, parallel to that of the country rock and to the contact with the country rock. The schistosity of the talc body is involved in small tight folds and broad rolls in precisely the same manner as that of the country rock. This may be explained either as a relic structure preserved in steatite and grit which was formed by the alteration of schist, or as a structure formed in the talc by folding later than the steatitization.

It is possible that much, perhaps even most, of the talc-rock exposed is not of ultramafic origin, but was formed by alteration of the schist. Nevertheless, the deposit is believed to be related to an ultramafic body.

Reserves. -- Reserves are certainly adequate for several probably for many, years at the present rate of production.

Locality 124

The Carleton talc quarry is located in west-central Chester township, 2.2 miles N. 85° W. of Chester Depot. The deposit lies at an altitude of 880 feet, about midway up the eastern slope of a steep hill. Total relief within a mile of the quarry is about 600 feet. The locality is well-known among mineral collectors for the variety of minerals that occur there. The quarry was operated for many years prior to 1943, when a serious cave-in cause the management to abondon it.

To reach the locality from Chester, drive westward on State Route 11 for 2.2 miles from the road bridge over the Middle Branch of the Williams River at the junction of State Routes 11 and 103; turn right on a dirt road and drive northwestward for 0.25 miles; turn left through a gate onto the quarry road and continue 0.1 mile to the quarry.

The nearest railroad is the Rutland, at Chester Depot, about 2.5 miles to the east.

Phillips and Hess (1936, pp. 343-345) describe the Carleton quarry (Vermont Mineral Products quarry) as an example of the higher temperature type of metamorphic differentiation at the borders of an ultramafic body. Gillson (1927, pp. 254-258) discusses the petrology and origin of the deposit.

Geology.-- The size and shape of the deposit are not known, but it is at least 300 feet long and 160 feet wide. The quarry is now filled with water and its depth is not accurately known, but it is probably at least 75 feet.

Serpentinite, grit, and steatite occur in the deposit. The steatite is at the margins of the body, next to the contact with the blackwall. Grit and serpentinite are somewhat irregularly distributed, but in general serpentinite forms the core of the body, with grit developed between the serpentinite core and the steatite, and also irregularly invading the serpentinite core.

The country rock is a feldspathic quartz-muscovite-chlorite gneiss or schist, with locally abundant tourmaline, garnet, biotite, amphibolite, and pyrite. At the contact with the steatite, the country rock is altered to biotite and chlorite schist, the blackwall.

The schistosity in the country rock strikes about N. 10° W. and dips 55° to 75° west. At the south end of the quarry the country rock and steatite are involved in several folds with amplitudes as much as 10 or 15 feet and widths from crest to crest as much as 30 feet. This folding affects both bedding and schistosity of the country rock, which are here parallel. The axial planes of the folds strike to N. 15° W. and dip 85° east to vertical; the axes of the folds plunge 30° to 60° to the north or northeast. Thus the axial planes of the folds strike nearly parallel to the regional schistosity but are appreciably steeper. In one of the synclinal folds some steatite with well-developed axial-plane schistosity is left. The underlying schist shows only a bedding plane schistosity. Here the schistosity of the talc is not an inherited feature retained in the alteration of the schist to steatite, and therefore the folding is probably later than the steatitization.

Reserves.-- The quarry was abandoned because of a serious cave-in which made continued operations impractical. Nearly all accessible grit and steatite have been exhausted.

Vermont Talc Co. quarry, Locality 126

The Vermont Talc Co. quarry is in northern Windham, 1.2 miles S. 60° E. of the junction of State Routes 11 and 121 in north Windham village. The deposit is exposed at an altitude of 1900 feet near the top of a broad hill. Total relief within a mile of the quarry is about 500 feet.

The quarry may be reached as follows: From Chester village, drive westward on State Route 11 for 10.5 miles from the road bridge over the Middle Branch of the Williams River at the junction of State Routes 11 and 103 to a point ¼ mile northeast of the junction of State Routes 11 and 121; turn left (east) on a dirt road and continue for 0.9 mile. Turn right and drive 0.3 mile to a fork in the road; take the right-hand fork and continue 0.2 mile; turn left onto the quarry road and continue about 0.1 mile to the quarry.

The Rutland Railroad at Chester is about 12 miles distant by road.

The quarry.-- Both underground mining and open-pit quarrying have been carried on at this locality.

At present only quarrying is practiced. The rock is broken by pneumatic drilling and by blasting, hand loaded into 1-ton railway cars, which are hand trammed to the foot of an inclined railway, and dumped into an electric-powered skip which hoists the ore to the loading bins. From the bins, the talc-rock is loaded into trucks and transported to the mill at Chester.

Geology.-- The ultramafic body is at least 700 feet long and is more than 300 feet and possibly more than 500 feet, wide. Grit and steatite are extensively exposed along the eastern part of the body. In the western wall of the quarry, and west of the quarry for a distance of 150 feet, a large mass of serpentinite is exposed. Though the western margin of the ultramafic body is not exposed, it is probable that the serpentinite mass represents the core of the deposit, and that grit and steatite exist to the west of the serpentinite mass.

Locally within the deposit, the grit contains so much carbonate that it is essentially a carbonate rock with a small amount of talc. A zone of steatite in the eastern wall of the quarry contains many small, irregular veins of chlorite a fraction of an inch to an inch or so wide. At the southern end of the lowest bench (altitude 1862 feet) several peculiar and interesting veins cut the grit. Seemingly these veins formed along joint surfaces because they are regular in attitude over areas of many square feet. The central part of each vein is white, flaky talc. Bordering the talc is coarsely crystalline, bright-green chlorite, grading into fine-grained, dull-green chlorite. Small (half an inch) rosettes of white, fine-grained talc are present in the fine-grained chlorite, which grades over a distance of about an inch into grit.

A schistosity almost parallel to that of the country rock is developed locally within the grit, and almost everywhere in the steatite. A number of shear zones or small faults cut the grit and steatite; how far they extend into the schist is not known. The faults vary considerably in attitude, but may be divided into four groups upon the basis of their attitudes: Those that (1) strike about N. 30° W. and dip steeply west or vertical; (2) strike N. 15° W. and dip 40° to 50° west; (3) strike N. 15° E. and dip steeply west; and (4) strike east and dip 65° to 75° south. Slickensides, which plunge moderately (2° to 50°, averaging about 25°) southward, are conspicuous on the first and second group.

The country rock is quartz-sericite gneiss and greenstone; the schistosity strikes N. 20° to 25° E. and dips steeply east or vertical. At the contact with the steatite the country rock is altered to coarse

biotite and chlorite schist; biotite occurs next to the contact for a width of about 6 inches, and chlorite outside the biotite zone for a width of 6 to 12 inches.

Reserves.-- Reserves are probably adequate for several years at the present rate of mining, but none is actually blocked out. If the postulated grit-steatite zone on the west margin of the deposit is present, the reserves may be large.

Localities 127 and 128

A large body of serpentinite and grit crops out in northern Windham township, 1.8 miles S. 55° E. of the junction in North Windham village of State Routes 11 and 121. Seven or eight hundred feet north-northeast of this locality is a small outcrop of grit. Likely the two localities are part of one body; so, the two will be described together. The large serpentinite-grit mass of Locality 127 forms a prominent rounded hill about 100 feet high, the top of which has an altitude of 2000 feet. The grit of Locality 128 crops out on the southwest side of the road at an altitude of 1930 feet. Total relief within a radius of a mile is about 400 feet.

To reach these localities from Chester, drive westward on State Route 11 for 10.5 miles from the road bridge over Middle Branch of the Williams River at the junction of State Routes 11 and 103 to a point ¼ mile northeast of the junction of State Routes 11 and 121; turn left (east) on a dirt road and continue for 0.9 mile. Turn right and drive 0.3 mile to a fork in the road; take the left fork and continue 0.9 mile to the second house on the right side of the road. The grit body of Locality 128 crops out on the southwest side of the road 100 feet southeast of the house. Locality 127 is 700 to 800 feet to the south-southwest.

The Rutland Railroad at Chester is about 13 miles distant by road.

Geology. -- The entire exposure at locality 128 is fine grained grit with abundant carbonate. A faint schistosity which strikes N. 60° E. and dips 70° SE is present locally in the grit. The only country rock exposed is greenstone, at least 40 feet thick, about 50 feet west of the grit outcrop. The foliation in the greenstone strikes N. 27° E. and dips 70° east.

The size and shape of the serpentinite-grit body at locality 127 has not been determined, but the deposit is at least 1000 feet long and 500 feet wide. Along the western side of the outcrop area a zone of grit and steatite at least 100 feet wide is exposed. The grit is of good quality. The remainder of the exposed area is entirely serpentinite. Much of the serpentinite is non-schistose, but a number of schistose zones were noted within the body. Locally within these zones the schistosity is folded in small, tight folds. Near the east-central margin of the exposure the schistosity in the serpentinite has a strike of N. 30° E. and a dip of 75° to the east. A small fold nearby has an attitude as follows: strike of axial plane N. 27° E., dip 80° eastward; plunge of fold axis 47° to the northeastward. Thus the axial plane of the fold is sub-parallel to the schistosity of the greenstones a few hundred feet distant, but is somewhat steeper. Whether this is a general relationship is not known.

Several hundred feet west of the grit at the western edge of the ultramafic body are several exposures of greenstone.

Reserves.-- Reserves at this locality are believed to be large and of good quality.

Barton talc quarry, Locality 129

The Barton quarry is an abandoned talc quarry in southwestern Chester township, 3.7 miles S. 48° W. of Chester Depot. The quarry is at an altitude of 1620 feet on the steep northeastern slope of a hill, whose summit is 2000 feet above sea level. Total relief within a mile is about 1100 feet.

To reach the quarry from the village of Chester, drive southward on the road to Grafton from its junction with State Route 11 for 1.7 miles; take the right fork and continue 1 mile to another fork in the road; take the left fork and drive 0.7 mile to where an old road branches off to the right (west). The quarry is at the end of this road, about half a mile distant.

The Rutland Railroad at Chester Depot is about 4 miles distant by road.

Geology. -- The quarry is about 150 feet long and 50 feet wide, and is elongate north-south. The deposit appears to consist entirely of grit and steatite; no residual serpentinite was noted. Actinolite is abundant at the outer part of the steatite zone. The country rock schist has been altered to chlorite for a width of 0.5 to 1 foot from the contact. The schistosity of both the steatite and the schists strike N. 15° E. and dips 55° to 70° westward. Minor folds of the schistosity in the steatite have axial planes that strike N. 30° E. and are vertical or dip steeply eastward, with axes that plunge gently to moderately south or southwest. A small cross-cutting granitic dike one foot thick is exposed in the west wall of the quarry.

Reserves.-- Reserves are probably small.

Davis (or Holden) talc quarry, Locality 130

The Davis (or Holden) talc quarry lies 2.1 miles S. 5° E. of Chester Depot in southern Chester township. The deposit is at an altitude of 1000 feet and is at the foot of the steep eastern slope of a hill whose altitude is 1200 feet. Total relief within a mile is about 800 feet.

To reach the locality from Chester, drive southward on the road to Grafton from its junction with State Route 11 for 0.65 mile. At this point, which is 0.15 miles beyond the first bridge over South Branch of Williams River and a few hundred feet before the second bridge, turn left and continue 1.5 miles. The quarry, whose location is marked by several buildings, is 100 feet or so west of this point.

The Rutland Railroad at Chester is about 3 miles distant by road.

The locality is described by Phillips and Hess (1936, pp. 345-348) as an example of the higher temperature type of metamorphic differentiation at the borders of an ultramafic body.

Geology. -- The ultramafic body is exposed intermittently along the western wall of the old quarry for a distance of more than 400 feet. The deposit consists of a series of lenses, each composed of a central core of flaky talc—acicular talc pseudomorphic after enstatite, according to Phillips and Hess (1936, p. 347)—and carbonate, with a little biotite near the margin of the core. Surrounding the central core is a thin shell of radiating actinolite, which is bordered by a shell of biotite.

The country rock consists of a feldspar-quartz-biotite gneiss, cut by pegmatite stringers and by at least one mafic dike. The schistosity of the gneiss strikes N. 5° to 15° E. and dips 30° to 40° west. The structure is complicated, however, by at least one very tight, rather large recumbent fold with an amplitude of at least several tens of feet, whose axial plane is about parallel to the general schistosity.

Reserves. -- The mineable material at this locality appears to be exhausted.

Locality 136

Several abandoned quarries are in what appears to be a single steatite deposit in southeastern Grafton, 2.1 miles S. 15° E. of the center of Grafton village. The deposit crops out at several places between the altitudes of 1500 and 1550 feet in a broad saddle. Total relief within a radius of a mile is about 600 feet.

To get to the locality from Grafton, turn south off State Route 121 immediately west of Saxtons River and drive southward for 2.3 miles on a dirt road. Park here and continue on foot along the left fork of the road for 1000 feet. At this point, opposite an old shack, a road branches off to the right (southwest). Between 1000 and 1200 feet along this road are several abandoned quarries on either side.

The Rutland Railroad at Chester Depot is about 9 miles away by road.

Geology. -- This locality was examined very briefly. The talc body, insofar as was seen, consists entirely of steatite and is tabular in form. The steatite consists of flaky talc, acicular talc probably pseudomorphus after enstatite or anthophyllite, and a small amount of carbonate. Only the upper contact is exposed at the places examined. The blackwall zone at this contact consists of coarse biotite and chlorite, which grades outward into pure chlorite. The country rock is gneiss, which strikes east of north and dips moderately to the northwest.

Reserves. -- The size and probable extent of the deposit are not known.

Suggestions for exploration and further geologic study

Geologic relationships are useful guides to exploration and evaluation of the potentialities of a talc deposit. It has been observed in Vermont that commercial talc deposits are associated with the verde antique type of ultramafic body, whereas none is known in partly serpentinized peridotite and dunite. This association may serve to predict whether an ultramafic body contains commercial talc. Criteria for distinguishing the two types of ultramafic bodies, discussed more fully on pages 7 and 8, may be tabulated as follows:

Type of ultramafic rock 1/ / Criteria	Verde antique type	Partly serpentinized dunite and peridotite
Weathering characteristics	Pale greenish-white to light buff on weathered surface.	Reddish brown on weathered surface; commonly referred to as "buckskin."
Rock types	Serpentinite, grit, steatite.	Large volumes of dunite and peridotite, minor or moderate quantities of serpentinite.
Species of serpentine mineral 2/	Antigorite.	Serpentine (plus chrysotile).
Abestos	Cross-fiber rare or absent; slip-fiber present at some localities in small quantities.	Both cross-fiber and slip-fiber common, possibly in commercial quantities.
Remarks	Considerable amounts of talc always associated; may or may not be in commercial quantity.	Commercial amounts of talc are not known to be associated.

[1]Ultramafic bodies intermediate between the verde antique type and the partly serpentinized dunite or peridotite type may be expected under conditions of genesis suggested on pages 7 and 8, although none has yet been recognized in the current studies.

[2]The nomenclature is that of Selfridge (1936, pp. 468-469).

Structural controls appear to be important factors in localization of talc within the verde antique type of serpentinite body. Steatitization commonly is greater at irregularities along the contact of the ultramafic body; rolls, folds, and "keels" are favorable locations for large grit-steatite deposits. Therefore, before exploration and development of a deposit are undertaken, an attempt should be made to locate such structural features. This is best accomplished by detailed geologic mapping on a large scale. Exploratory drilling, trenching, and mining may then be carried out more intelligently.

Faults locally cut the talc deposits and the country rock. Most of the faults are of small displacement and do not so seriously complicate the form of a deposit that a talc body is completely offset and its continuity lost. However, in areas that contain numerous faults, drifting and stoping operations may be seriously handicapped through weakening of the walls of mine openings and through contamination of the grit and steatite with gouge and breccia fragments of wall rock. Some of the barren "cinders" are of fault origin. Thus faults constitute more of an engineering than a geologic problem.

Geologic study of talc deposits may not yield uniformly satisfactory results. In the first place, many ultramafic bodies are extensively covered with surficial deposits that prevent direct observation. The structural features of some are complex and irregular and the different features, particularly folds, intrusive contacts, and faults, are so intricately related that it is difficult or impossible to evaluate them properly at the present time. The grit and steatite zones are relatively easy to delimit in the simpler deposits. Detailed geologic study, supplemented perhaps by exploratory diamond drilling and trenching, should, under favorable conditions, enable a geologist to infer the approximate form and dimensions of a deposit and arrive at the order of magnitude of the reserves. They should enable the mining engineer to determine the best plan for development and exploitation. Under only moderately favorable conditions, geologic study will enable the geologist and engineer to classify a deposit as favorable or unfavorable for development.

Many years ago, when practically all of the talc mines now operating were opened, labor was readily available, operations were on a comparatively small scale, and only a relatively small outlay of capital was necessary to begin mining operations. Consequently, it was possible to open a mine without risking a large sum of money. Under those conditions, geologic studies of deposits about to be exploited were considered unnecessary. At present, however, with the large initial outlays of capital required to begin mining operations, a deposit should be exploited only after thorough geologic study.

The study of the regional geology of the belt of ultramafic rocks in Vermont is incomplete, and it is not yet possible to explain the great range in degree of steatitization of ultramafic bodies. It is hoped that some explanation will soon be forthcoming to aid in predicting the economic value of talc deposits and to facilitate their exploration. One critical problem to be solved in this connection is that of the source of the solutions responsible for steatitization. It has been pointed out in earlier discussion (pp. 1 and 8) that the solutions are probably derived from outside the ultramafic body. The solutions may have originated in the adjacent wall rock formations under conditions of regional metamorphism, or they may have come from greater depth as emanations from igneous bodies not exposed. Should the adjacent regionally metamorphosed country rock be the source, mapping of the regional stratigraphic and metamorphic patterns may be expected to furnish supporting evidence and to furnish information useful in exploration. If igneous rocks at depth constitute the source of solutions, regional mapping may reveal the presence of such rocks and of structural features through which the solutions gained access to the ultramafic bodies. With these data available, differences in the talc content in ultramafic bodies may be explained and the areas most favorable for exploration delimited.

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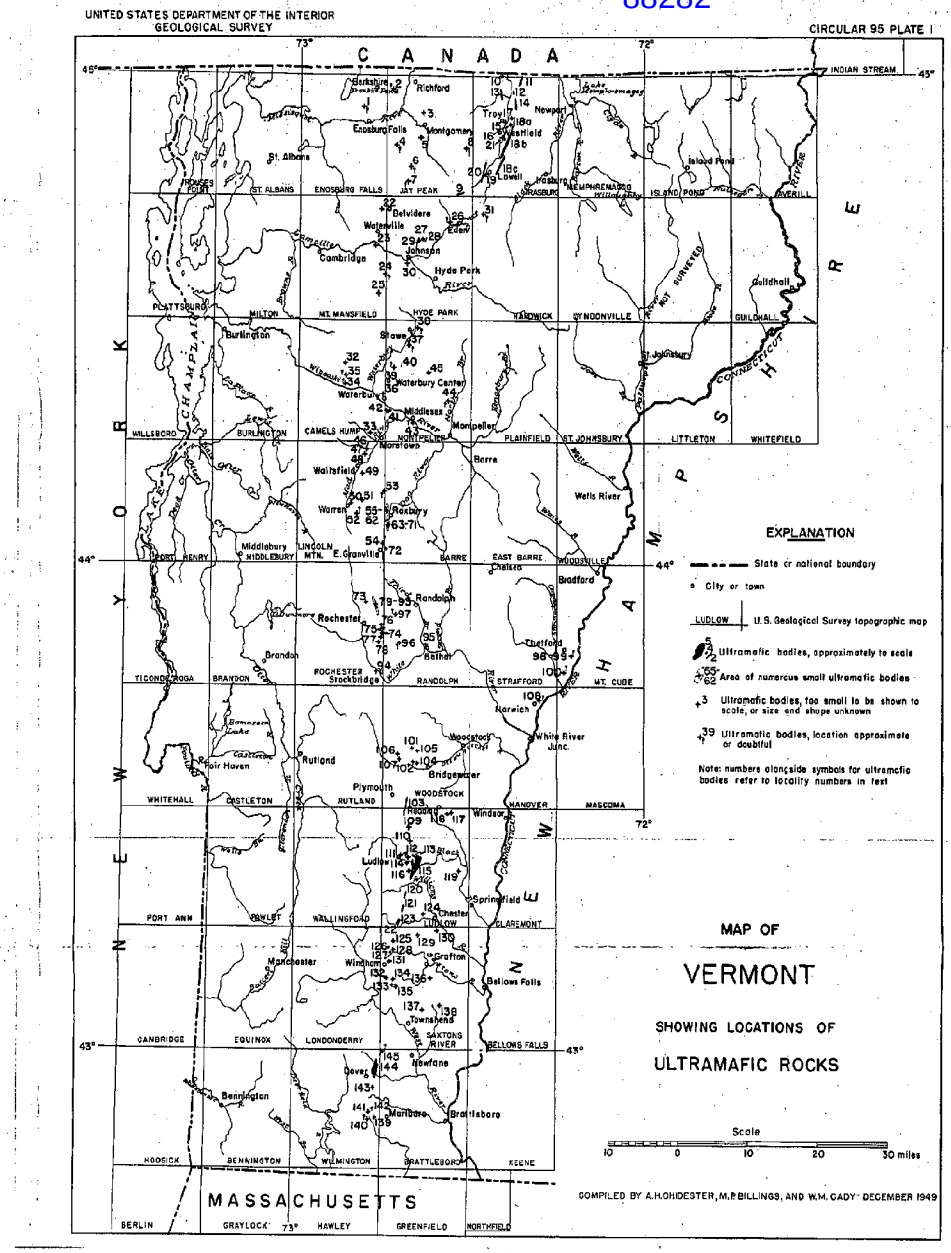
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CIRCULAR 95 PLATE I
CANADA
MASSACHUSETTS
EXPLANATION
State or national boundary
City or town
LUDLOW U.S. Geological Survey topographic map
Ultramafic bodies, approximately to scale
Area of numerous small ultramafic bodies
Ultramafic bodies, too small to be shown to scale, or size and shape unknown
Ultramafic bodies, location approximate or doubtful
Note: numbers alongside symbols for ultramafic bodies refer to locality numbers in text
MAP OF
VERMONT
SHOWING LOCATIONS OF
ULTRAMAFIC ROCKS
Scale
10 0 10 20 30 miles
COMPILED BY A.H.CHIDESTER, M.P.BILLINGS, AND W.M.CADY DECEMBER 1949

Exhibit 20

MINERAL RESOURCE PROVINCES OF VERMONT

A current look at Vermont's mineral resources potential and mineral industries.

February 1982

by

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INDEX

THE CARBONATE PROVINCE

MARBLE

Vermont's dimension stone marble is known the world over. The Danby Imperial white marble, the Isle La Motte black marble (limestone) and the green Verde Antique (serpentinite) are among the industries most noted products. The Verde Antique has been discussed under the ultramafic province since it is truly a product related to ultramafic geology and not carbonate geology. The major operator of Vermont's marble industry is the Swiss firm OMYA, Inc., a Pluess-Staufer Company.

In addition to dimension stone, the Vermont marble industry supplies an increased international demand for a finely-ground calcium carbonate product. Quarries at East Middlebury and Wallingford supply the White Pigment Co. mills at New Haven Junction and Florence, and the Smokerise quarry at Brandon supplies the Vermarco Company mill at Florence. The OMYA, Inc. mill at Florence is also supplied by the white marble quarry at East Middlebury.

The most sought after marble for both the dimension stone and ground products industries are the white marbles. The Columbian member of the Ordovician Shelburne Formation where thickened by folding or faulting has proven to be the most successful geologic target for the industry. The quarries listed above are located in this stratigraphic-structural setting. The Shelburne Formation is shown on the state geologic map (Doll, 1961) in the Champlain and Vermont Valleys from Colchester to Bennington. Minor production has come from the Upper Cambrian Sutherland Falls member of the Clarendon Springs Formation, and from the Lower Ordovician Bascom Formation.

The fossiliferous Crown Point member of the Middlebury Formation harbors the one black marble (limestone) quarry used for dimension stone. The quarry is located on Isle La Motte in Grand Isle County. It was last worked in the late 1960's-early 1970's. This limestone abounds in fossil remains of Ordovician gastropods, Maclurites magnus and Raphistoma striatum.

The Danby Imperial quarry located on the northeast flank of Dorset Mountain in Danby, Vermont is perhaps the world's largest operating underground marble quarry. Stone from this quarry also is located in the Columbian white marble of the Ordovician Shelburne Formation.

The Smokerise quarry at Brandon commenced operation on December 13, 1979 and is the first new quarry to come on line since 1964. Rock from this quarry is supplying the mills at Florence, once supplied by the Loveland quarry which was depleted in 1979. Several former dimension stone quarries

are currently being considered for re-activation to supply the ground products mills.

LIMESTONE

With the exception of the black limestone quarry on Isle La Motte which supplies the dimension stone industry, all other limestone quarries produce crushed stone for a variety of uses. The primary use is for road base and bituminous concrete aggregate for highway construction. Both permanent quarries and small single-contract rock-borrow quarries exist throughout the (marble-limestone) Carbonate Province.

The permanent quarries are located in Swanton (The Swanton-Shelburne Limestone Corp.), Winooski (Frank W. Whitcomb Construction Corp.), Shelburne (The Swanton-Shelburne Limestone Corp.) and New Haven (Pike Industries Inc.). The marble companies discussed above also produce crushed stone for aggregate, agricultural lime and other uses.

Several formations with dominantly carbonate lithologies are exploited by the crushed stone industry. The Beldons member of the Ordovician Chipman Formation is quarried at Swanton and New Haven, the Ordovician Shelburne Formation provides the rock for the Shelburne Limestone Corp. quarry at Shelburne, and the Cambrian Winooski Formation is quarried in Winooski by Whitcomb. These formations are present as disconnected belts throughout the Carbonate Province.

The northwestern margin of the Carbonate Province is in New York state and does not show on the mineral resource map of Vermont (see Plate I). This margin extends from Champlain (New York) through Chazy (New York), to Ticonderoga (New York) and back into Vermont at Chipman Point.

Crystalline limestones associated with the Devonian Waits River Formation in eastern Vermont, and carbonate lenses of limited occurrence in other formations (Pinney Hollow, Underhill) have been quarried in the past but offer no significant resource.

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THE GRANITIC PROVINCE

Granitic plutons assigned to the Devonian New Hampshire Pluton Series are known to exist the entire length of the state from the Black Mountain pluton in Dummerston to the large pluton of Averill Granite in Norton and Averill in northeastern Vermont. Although granite has been quarried in nearly all these plutons at one time, the most active quarries today are in the Barre pluton at Graniteville and Websterville. The dominant exposures of granitic rock of the New Hampshire Series lie north and east of Barre. This region can be designated as Vermont's Granitic Province and it is here that future exploitation will most likely occur.

Barre Granite: Barre granite is the name given to the medium-textured uniformly gray colored granodiorite. It was mapped and described by Murthy(1957). Two quarry companies operate five quarries in the Graniteville-Websterville mining district which is approximately three miles southeast of the town of Barre (pronounced like "berry"). The Rock of Ages Corp. operates the Wetmore-Morse, Smith, Rock-of-Ages, and Pirie quarries, and the Wells-Lamson Quarry Co. operates their Wells-Lamson quarry at Websterville.

Woodbury Granite: The Woodbury Granite mapped and described by Konig(1961) is found in several small exposures in the towns of Woodbury and Hardwick. The Woodbury granite is light to medium gray, generally with medium-textured grains, however grain size and texture vary in the several exposures in the region. Quarries east and northeast of the town of Woodbury once supplied a very prosperous granite industry in Hardwick. The center of the industry has since shifted to the Barre area and only one operator, John Swenson Granite Co. (Concord, N.H.), is currently quarrying the Woodbury granite.

Adamant Granite: The Adamant granite mapped and described by Cady (1956) and Konig (1961) occurs as sills trending northeasterly in the village of Adamant (Calais township). This granite is a mottled gray varying in texture from medium-coarse equigranular in the thicker sills to porphyritic in the thin sills. Until recently the Garand Teed Quarries, Inc. produced rough blocks from a quarry in one of the thicker sills of Adamant granite. The present owner does not anticipate further commerical use of the Adamant quarries.

Derby Granite: The Derby granite (not officially named) has been mapped and described by Doll (1951). It occurs in several large plutons exposed in the towns of Derby, Charleston, Barton, Irasburg and Westmore. The granite is light to dark gray, medium to coarse grained and varies from equigranular to porphyritic texture. The old Willey Granite Quarry northwest of Derby Center is currently operated by Granite Hills, Inc. providing rough granite blocks for the Rock of Ages Corp.

COLORED GRANITES

Bethel White Granite: The Bethel granite was mapped and described by Ern (1963). One small exposure of this granite is located on Quarry Hill northeast of the village of Bethel. A large quarry which provided highway aggregate for construction of Interstate 89 can be seen just west of this highway approximately two miles north of Interchange #3. The Rock of Ages dimension stone quarry is a short distance west of this site.

The rock is medium to coarse grained and nearly pure white. It is composed almost entirely of leucocratic minerals quartz, oligoclase, orthoclase, microcline and muscovite. Minor quantities of biotite and epidote provide cloudy, dark splotches in the rock. The rock has been classed as a quartz monzonite (Ern, 1963).

Braintree Granite: The Braintree granite was also mapped and described by Ern (1963). This pluton is located west of the village of East Braintree and like the Bethel White granite pluton lies to the south of the main granitic province. This granite, where quarried has a medium gray color with a faint pinkish tint. It is a medium to coarse textured, equigranular rock. The pluton is also composed of a dioritic phase that makes up the western half of the Braintree pluton. Mr. John Murray of Randolph actively quarried the rock for personal use only. The quarry property is currently owned by Mr. Murray.

Extensive exploration in Vermont seems unwarranted. The various occurrences of granitic rocks are well known. There is an interest in locating colored varieties of igneous rock suitable for monumental and dimension stone. Known occurrences of unaltered, medium to coarse grained, mafic igneous rocks are few and the expectations of finding large plutons of such rocks in Vermont are minimal. Rock within the boundaries of current mining districts is apparently ample for foreseeable needs. Numerous abandoned granite quarries exist throughout the granitic province and in other small granitic plutons outside the province. These quarries have exploited rock of Precambrain age in a small granitic body west of Tyson, Vermont, and Mesozoic granitic rocks at Mount Ascutney in Brownsville (West Windsor).

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THE KAOLINITIC CLAY PROVINCE

The kaolin province forms a narrow belt along the base of the Green Mountain Front in western Vermont. The history of production goes back to 1793 when local clay was used for the manufacture of pottery and fire-brick by Norton Pottery near Bennington. Deposits have been reported in Pownal, Bennington, Shaftsbury, Dorset, South Wallingford, Tinmouth, North Clarendon, Rutland, Brandon and Monkton. These deposits form discontinuous links in the kaolin belt.

Iron (as limonite) and manganese (as psilomelane, pyrolusite, and manganite) ores associated with the kaolin deposits were mined until the early 1900's, iron ore at Brandon (Forestdale) and Bennington, and manganese ore at South Wallingford. Early scientific workers (Dale 1903-04, Woodworth, 1903-04, Burt 1927-28) in the province attribute the origin of the kaolin to the residual weathering of feldspathic rocks caught up in the fault zone along the western base of the Green Mountains. More recently Ogden (1960 and 1969) has proposed a hydrothermal origin for the Monkton Kaolin deposit.

Kaolin deposits in the Shaftsbury-Bennington area were actively mined and processed and provided raw material for the paper, pottery, fireclay and brick industries. Greatest production came in 1930 when 11,000 tons of clay was mined by the Vermont Kaolin Corporation. The clay mining business in southwestern Vermont was a victim of the business depression of the 1930's. In recent years (1977) the Darlington Brick & Clay Products Company of Darlington, Pa. and (1979) the Holland Chemical Company of Adams, Ma. have shown an interest in these deposits.

The Brandon (Forestdale) kaolin deposit was worked from 1902 to 1925 and produced 80,000 tons of kaolin. This deposit is reported to be practically worked out (Jacobs, 1933-34).

The Monkton kaolin industry got underway in the early 1800's having been perhaps the first kaolin deposit to be discovered in the U. S. in 1792. The American Kaolin Company produced an average of 2000 tons per year from 1883 - 1890. Various firms produced kaolin intermittently until 1930. From 1930 until 1944 the firm of Frank E. Bushey & Sons produced about a thousand tons per year to supply the needs of the Rutland Fire Clay Company. In 1956 the Vermont Kaolin Corporation purchased mineral rights from Mr. Leon V. Bushey. After several years of exploratory work, laboratory testing and plant construction, only 9,235 tons of clay were produced and in 1966 the operation closed down. Apparently the beneficiation process was not sophisticated enough to remove discoloring impurities, particularly graphite material. In addition, the natural product being quite coarse textured required expensive grinding, separating and drying techniques. The cost to market a product meeting the specifications of the modern paper making industries became prohibitive.

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THE OIL AND GAS PROVINCE

The first attempt to find oil and gas in Vermont was made in the Lake Champlain Basin in the spring of 1957. A wildcat well was drilled to a depth of approximately 4,500 feet on the Isadore Yandow farm four miles northwest of St. Albans. Since that time four additional wells have been drilled in the Champlain sedimentary basin, the Gregoire I and II drilled at Mallet's Bay in Colchester in 1959-60, the Petrofina well drilled on the Harry Hutchins farm in So. Alburg in 1964, and the E. S. Baker #I well drilled in 1968 on the Everett S. Baker farm on Grand Isle. Some gas shows were reported, but all wells were abandoned. The deepest well (Gregoire I) is reported to have penetrated to a depth of 5,075 feet. Although commercial quantities of natural gas have been discovered in the Canadian extension of the Champlain sedimentary basin little interest has been generated in Vermont since the abandonment of E. S. Baker #I at 3,500 feet.

The Cambrian Potsdam formation is believed to be the potentially productive horizon, as well as bioherm and biostrome zones in carbonate rocks. In the Champlain basin Ordovician dolomites and shales thickened by faulting and folding cover the Potsdam. A potential for oil and gas traps in sedimentary horizons beneath the Green Mountain overthrust sheet (northern extension of the Eastern Overthrust Belt) extends the province eastward beyond the Green Mountain Front.

There are occurrences of natural gas in water wells in northwestern Vermont. A report was made by the Federal Energy Research and Development Administration in 1975 on the presence of soil gas in the Milton area. The amount and nature of this gas being comparable to that found above productive gas fields elsewhere. This evidence plus positive finds of commercial quantities of natural gas in Canada encourage continued speculation on the oil and gas potential of the western Vermont sedimentary basin. A proposal submitted to the Federal Energy Research and Development Administration in 1976 by the Vermont State Geologist and the Vermont Energy Office to drill a deep stratigraphic test hole and hydrocarbon probe was not funded.

The area west of a line drawn somewhat west of the central spine of the Green Mountains from Richford (north) to Stamford (south) can be considered as Vermont's Oil and Gas Province. The results of future exploration may alter the dimensions of this province.

In 1981 the Ohio Oil and Gas Company, a leasing brokerage from Fowler, Ohio obtained oil and gas leases on over 250,000 acres in western Vermont. In January of 1982 Columbia Gas Transmission Company and Louisiana Land and Exploration Company announced the purchase of these leases from the Ohio Company, and their intent to start seismic exploration in the summer of 1982.

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THE SLATE PROVINCE

Current slate production comes from the Cambrian St. Catherine Formation and the Ordovician Poultney and Indian River Slate Formation as mapped by Shumaker (1967) which are dominant formations within the Taconic Allochthon in southwestern Vermont (see Mineral Resource Province Map). An outline of this formation essentially parallels the margins of the slate province. The Vermont portion of the Vermont-New York Slate mining district is located in a narrow belt bordered on the west by the state line and on the east by the thrust line delineating the western margin of the western Bird Mountain Slice of Shumaker (1967).

Some of the first slates to be quarried in Vermont came from the Devonian Littleton Formation in Dummerston, Brattleboro and Guilford in southeastern Vermont. These quarries were mentioned in the first state geologist's report on the Geology of Vermont (Adams, 1845). Slate has also been quarried from the Devonian Northfield Formation in Northfield. These slates are black or dark gray in color and perhaps are better classified as phyllites. There has been no commercial production from these quarries since the early 1900's.

The current production of slate in Vermont comes from the Vermont-New York Slate Mining District in southwestern Vermont-east central New York. Approximately ten quarries are currently being operated in Vermont. The quarrying and milling operations employ approximately 300 people and the size of the operations vary from a two or three man family working part-time, to the larger quarrying-milling operation of Vermont Structural Slate Co. The Vermont-New York slates are unique in durability and color. The colors are red, unfading green, fading green (will turn brown in time), purple and mottled (green and purple). The slate is used for floor and counter tile, roofing slate, flagging, monumental, building veneer and other structural items.

The U. S. Bureau of Mines is currently conducting research on the use of waste slate as a resource. Several products have been produced at the research level. These include glass ceramics and fibers, light weight concrete aggregate and skid resistant highway aggregate. Whether or not these products can be produced and marketed economically is not yet known.

Vermont slate supplies local, national and international markets.

Current practice of the slate industry is to continue to deepen existing quarries or to extend them along strike. Also several old quarries have been reactivated. An abundance of resource has not yet required off-property exploration.

Arthur D. Little, Inc. completed a comprehensive study of the Vermont-New York Slate industry in October, 1980. This study conducted under a U. S. Bureau of Mines contract presents several recommendations for improving quarrying, milling and marketing techniques in the slate industry.

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THE SULFIDE PROVINCE

Vermont's Orange County Copper Mining District and the Essex Copper mine lie within the Connecticut Valley-Gaspe' Synclinorium and Bronson Hill Anticlinorium Tectonic Provinces and the large Appalachian province of stratabound (massive) sulfide deposits (Gair and Slack, 1979). Other small mines, prospects and noted metallic sulfide mineral occurrences lie within this major tectonic-mineral province. Isolated occurrences are known within the Green Mountain Anticlinorium tectonic province.

Lead-zinc sulfide mineralization is known to exist in the Cambrian Winooski-Dunham lithologies which extend from Franklin (north) to Bennington (south) Counties. The only known mines (now abandoned) were the Oram prospects at Brandon. This narrow, linear province with sporadic occurrences of galena-sphalerite may be thought of as the Foreland lead-zinc province. Lead-zinc occurrences in this province may be similar to those in the southern Appalachian zinc province where the sulfide mineralization is associated with both tectonic and collapse breccias or localized along faults and fault intersections in Cambrian (Knox-type) dolomitized limestones. This Foreland lead-zinc province warrants detailed exploration.

No metallic minerals are currently being mined in Vermont. The sulfide ores in the Orange County district were discovered in 1793 and mines began to operate for the production of copper in the early 1830's. Vermont was the chief copper producer in the United States until the Michigan copper ores were exploited in 1846. The Vermont mines operated sporadically through the 1950's. The closing of the Elizabeth mine at South Strafford in 1958 brought an end to metal mining in Vermont. Ore minerals have not been exhausted in the Orange County copper district. However, the ore grade is marginal and the complexity of the structure makes mining extremely difficult. No strong interest has been shown in the district for more than twenty years.

The district was left to remain as a significant scar on the surrounding landscape. Nature has been incapable of healing the acid-sulfur wastes. Strong environmental opposition is likely to deter future mining in the district unless it can be demonstrated that the present day mining technology is capable of rehabilitating the landscape including existing as well as newly generated wastes and mining scars.

Known sulfide mineralization including old prospects and mines are indicated on the Mineral Resource Province Map by the letter S. No attempt has been made to outline a province.

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THE ULTRAMAFIC PROVINCE

Asbestos: The asbestos mining district is located in the upper Missisquoi River Valley in Orleans and Lamoille counties. Current mines and milling operations are located on the eastern flank of Belvidere Mountain in the towns of Lowell and Eden. The mines and mill are being operated by the Vermont Asbestos Group, a primarily worker-owned industry whose main office is at Hyde Park, Vermont. Although production is small compared with that of producers in Quebec, Vermont ranks second in the production of chrysotile asbestos in the United States. Vermont's asbestos industry supplies both national and foreign markets.

Asbestos minerals are associated with serpentinized ultramafic bodies. The larger bodies are composed of central cores of massive dunite and peridotite which grade outward to massive or sheared serpentinite. Chrysotile asbestos occurs sparcely as cross-fiber veins in the more massive portions of the ultramafic bodies and as slip-fiber veins in the highly sheared serpentinites.

Modern theories on the tectonic emplacement of the ultramafic bodies may modify exploration procedures and encourage more extensive off-property searches. Current industry practice involves the expansion of existing open pit mines which has been successful in meeting market demands.

The Vermont Centennial Geologic map (Doll, 1961) shows the "ultramafic belt" extending the full length of the state with ultramafic bodies located in the Hazens Notch, Stowe, Ottauquechee, and Missisquoi Formations of Cambrian and Ordovician age. This map, with some modification, (see Mineral Resource Province Map) serves as a mineral province-mineral potential map. The Upper Missisquoi Valley asbestos mining district occupies the northern extremity of the ultramafic province.

Current environmental concerns regarding the protection of the health of asbestos workers and users has placed stringent air quality standards on the mining and milling of asbestos in the United States. Former user markets for asbestos are seeking substitutes. Both factors have had a major impact on the Vermont asbestos industry.

Talc and Soapstone: Like the asbestos mineralization described above, talc (and its massive variation - soapstone) is associated with serpentinized ultramafic bodies. The ultramafic bodies containing talc (steatite) are composed of a central core of serpentinite surrounded by a shell of talc-carbonate rock followed by an outer shell of talc (steatite). The production of talc and serpentine asbestos are genetically related but the steatitization is the latest, more extended metasomatic event which did not affect all of the ultramafic bodies in the province. Metasomatism involved the movement of H_2O, CO_2, MgO and SiO_2.

The talc-soapstone mineralization coincides with that described above for asbestos and is included within the ultramafic province. Known occurrences in north central Vermont are at Johnson (currently being mined by Eastern Magnesia Talc Co.), the Rousseau prospect, and Sterling Pond prospect in Lamoille County, the Barnes Hill, Waterbury and Mad River localities in Washington County, and the East Granville locality in Orange County. These known occurrences are contained in the northern talc mining district (see Plate I).

The talc mines of Windsor Minerals Inc., in Hammondsville and Ludlow, the Vermont Talc Company mine in Andover, and the Vermont Soapstone Company mine in Chester are included in the southern talc mining district (see Mineral Resource Province Map).

Vermont leads the nation in talc production. Products manufactured from Vermont talc are popular in the national and international marketplace.

Verde Antique (Serpentinite): "Verde antique marble" is the commercial name applied to the highly polished dark green serpentinite which has shear fractures cemented by veins of white carbonate mineralization. Verde antique is currently mined by the Vermont Marble Company (OMYA) at Quarry Hill, Rochester, Vermont. An abandoned verde antique mine is located in Roxbury. Verde antique quality serpentinite is also found at the Waterbury, Barnes Hill and Mad River localities. These serpentinite bodies are included in the northern talc mining district.

Because of the natural mineralogical associations of serpentine asbestos and talc similar environmental health concerns pervail in the mining, milling and product use where these resources are concerned. Particular attention must be given to quality control where these products are sold for human consumption.

Chromite: Chromite mineralization is known to exist in several of the serpentine bodies. Noticeable quantities of chromite have been encountered at the Rochester verde antique quarry and Belvidere Mountain.
Magnetite: Magnetite has been mined in Troy, Vermont.
Ultramafic Rock as a future resource: Future resources may be realized from the use of ultramafic rock as a heat retention material in solar heat storage facilities. Research on serpentinite mine waste conducted in Canada (University of Sherbrooke) and in the United Stated (Bureau of Mines, Federal Highway Administration) has produced several potentially marketable products. Among these are light weight concrete aggregate, refractory bricks, and synthetic skid resistant road aggregate.

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The Uranium Provinces

Knowledge of the existence of anomalous radioactivity in various geologic settings in Vermont dates back to the early 1950's. Reconnaissance surveys of Vermont's current and abandoned quarries and mines, and old mineral prospects conducted by the U. S. Geological Survey in cooperation with the U. S. Atomic Energy Commission (McKeown, 1951, Grauch and Zarinski, 1976, and U.S.A.E.C.-U.S.G.S. report RME-4106 TID UC-51, 1969) confirmed the presence of anomalous radioactivity and in some cases uranium mineralization at several localities. A sporadic search for uranium and other radioactive minerals continued through the 1960's and 1970's, the most noted being that of the National Uranium Resource Evaluation program which is being conducted by the federal government (ERDA now DOE).* In recent years (1978-1979) private uranium firms started to explore in Vermont. Discoveries of ore grade mineralization in Precambrian terrane of southern Vermont prompted extensive land leasing for exploration and mining rights in the vicinity of Jamaica, Vermont. Citizen concern developed into well organized opposition to exploration, mining and milling of radioactive minerals in Vermont. Restrictive legislation was passed in 1980 that discouraged industry from further exploratory work in Vermont.

The Sedimentary Province

Uranium and phosphate mineralization is known to coexist in Franklin and Chittenden Counties. Uranium is present in a uranophosphate mineral, hydroxylapatite, where uranium substitutes for calcium in the mineral structure. The mineral occurs in clasts and as cement in an

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*ERDA = Energy Research and Development Administration
DOE = Department of Energy

intraformational breccia-conglomerate in the Cambrian Clarendon Springs Formation. The Clarendon Springs Formation extends (in western Vermont) from the Canadian border at Highgate to Bennington.

Radioactive anomalies have been identified in the Clarendon Springs Formation by ground surveys at Highgate, Milton and Shelburne. Samples collected from the anomalous rock at Highgate and Milton have been analyzed for uranium, thorium and phosphate content:

HIGHGATE	MILTON
U_3O_8 = 317 ppm	U_3O_8 = 0.04%
ThO_2 = 34 ppm	ThO_2 = 9 ppm
P_2O_5 = 25.64%	P_2O_5 = 16.98%

In the winter of 1969-1970, Rio Algom, a Canadian mining firm, conducted a limited (2 holes) core drilling program on the Highgate anomaly after drilling several holes on the same anomaly in Canada. The uranium analyses on several samples representing 756' of core produced results ranging from 0.02 lbs/ton to 0.46 lbs/ton. At the time this was considered to be considerably below ore grade.

An aerial radiometric survey conducted in 1964 by the U. S. Geological Survey in cooperation with the U. S. Atomic Energy Commission (Popenoe, 1964), covered portions of southern Vermont. This survey identified radioactively anamalous areas (see Ratte' and Vanecek, 1980, Radioactive Anomaly Map of Vermont).

The Texas Instruments Corporation flew an airborne radiometric survey in 1976 for the National Uranium Resource Evaluation program (NURE). This survey covered all of Vermont (as well as New York and other New England states). The Milton and Shelburne anomalies as well as anomalies near Mechanicsville and Monkton Ridge were detected, however, the Highgate anomaly was not picked up by this survey. To the south in the Vermont

Valley anomalies were located near Tinmouth and Danby by both aerial surveys (Popenoe, 1964 and Texas Instruments, Inc., 1976). These anomalies are associated with the Clarendon Springs Formation or similar lithologies (Dunham Formation).

The U.S.A.E.C. report (RME-4106) indicates anomalies exist at the Lyon Hill* Lead-Zinc prospect in Leicester and at the Brandon "Silver" mine** in Brandon. These were not detected by the Texas Instruments airborne survey but are believed to be located in Clarendon-Dunham lithologies.

The Crystalline Province

Vein-type. Vein-type occurrences within strata-bound sulfide deposits are known to exist in Vermont's metamorphic terrane. The old Udall Copper mine at Wolcott, first reported by Butler, et. al. (1962), is located in Cambrian-Ordovician schist of the Stowe Formation. A sample from this site was analyzed for the U.S.A.E.C. (in RME-4106) and reported to contain 0.06% uranium. Anomalous radioactivity is reported (in RME-4106) at the Old Boston Copper mine in West Berkshire, and at the Sherbrook Lead prospect*** in Newport. No analytical data is available from these last two reported "probably vein-type" occurrences in Cambrian-Ordovician schist. These localities were not detected by the Texas Instruments, Inc. airborne survey.

Precambrian. The first report of anomalous radioactivity in Vermont's Precambrian terrane (located in the central Green Mountains

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*Location not well documented.

**Not the same as the Brandon lead-zinc prospect in Forestdale but located on the hill (elev. 1209') east of Sugar Hollow (see U. S. G. S. 7 1/2-minute quadrangle Brandon, Vermont).

***Location not well documented.

from Lincoln south to the Massachusetts border in Stamford, Readsboro and Whitingham) was at Snow Valley, in Winhall. This anomaly was reported in the U.S.A.E.C.-U.S.G.S. reconnaissance report RME-4106, TID UC-51. Analytical data is available (McHone and Wagener, 1980). This anomaly was not detected by the 1976 airborne survey conducted for the NURE program by Texas Instruments, Inc., however, the anomaly does show up on the 1964 U.S.G.S. aeroradioactivity survey (Popenoe, 1964).

Uranium mineralization in Vermont's Precambrian terrane (all rock types are metamorphic and undifferentiated--known as the Mt. Holly complex) is stratigraphically and structurally controlled having been mobilized and reconcentrated during subsequent Paleozoic metamorphic events. The mineralogy of these Precambrian occurrences is not well known and mineral associations vary from place to place. Radioactive anomalies are associated with quartz-tourmaline pegmatite in micaceous quartzites and gneissoid feldspathic quartzites. Biotite and graphite-rich zones in quartzite also show anomalously high radioactivity. Dark, schist-like occurrences of fine-grained biotite and tourmaline, probably resulting from hydrothermal alteration, in sheared quartzite are often highly radioactive.

Samples collected in the vicinity of Ludlow (Okemo) Mountain in the towns of Mt. Holly, Ludlow and Weston were analyzed in the fall of 1979 for the Vermont Division of Geology and Earth Resources, Agency of Environmental Conservation. The results are as follows:

- Okemo Mt. (top near fire tower) 3000 ppm or 0.397% U.
- Grant Brook (near South Mt., Ludlow)

  1. elev. 2105' 105 ppm U.
  2a. elev. 2040' 750 ppm or 0.075% U.
  2b. elev. 2040' 520 ppm or 0.06% U.

- Route 155 (approx. 1 mile north of Rte. 155-Rte. 100 intersection) 28 ppm U.

The Grant Brook anomaly was detected by the Texas Instruments, Inc., aerial survey and the Ludlow (Okemo) Mountain anomaly by the U.S.G.S. airborne survey (Popenoe, 1964).

Both aeroradiometric surveys detected additional anomalies in both Precambrian and Paleozoic terranes. Ground checks of these anomalies have been conducted and samples collected for assay by the NURE program geologists. The results have been published in reports listed in the uranium bibliography (McHone and Wagener, 1980, and Field and Truesdell, 1980).

The Granitic Province

Anomalous radioactivity and the potential for uranium occurrences exist in granitic rocks and associated pegmatites of the Devonian New Hampshire plutonic series (northeastern Vermont), and the Jurassic-Cretaceous White Mountain plutonic series (Mt. Ascutney in Brownsville, Granite Hill in Cuttingsville, Barber Hill in Charlotte, and Monadnock Mt. in Lemington). The Popenoe (1964) aeroradiometric survey recorded an anomaly at Granite Hill and Mt. Ascutney, and one in the Devonian pluton at Bellows Falls-Walpole, New Hampshire. No anomaly was detected by the Texas Instruments, Inc., airborne survey at Barber Hill. Neither survey covered the area of Monadnock Mt. in far northeastern Vermont.

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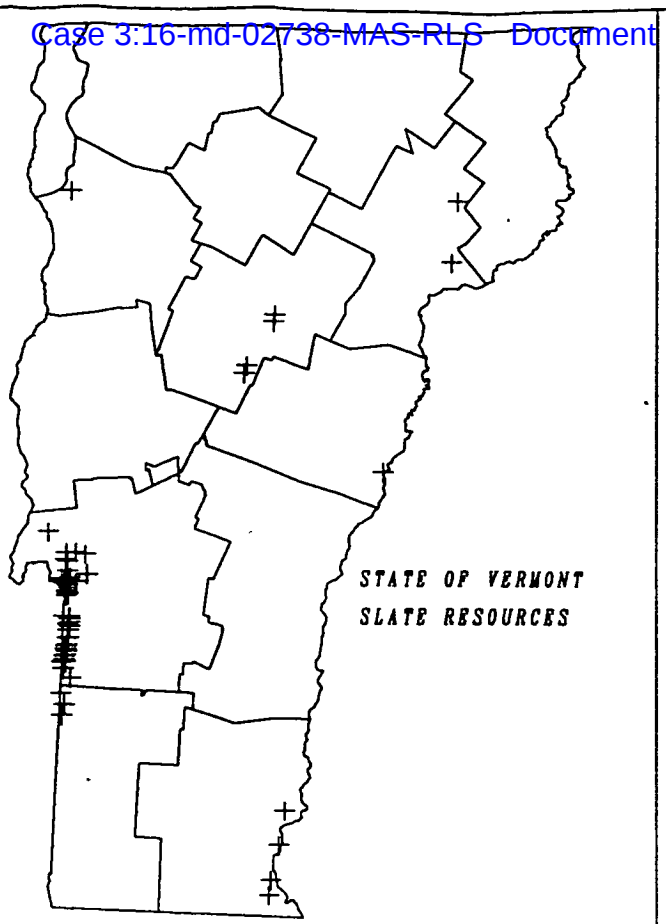
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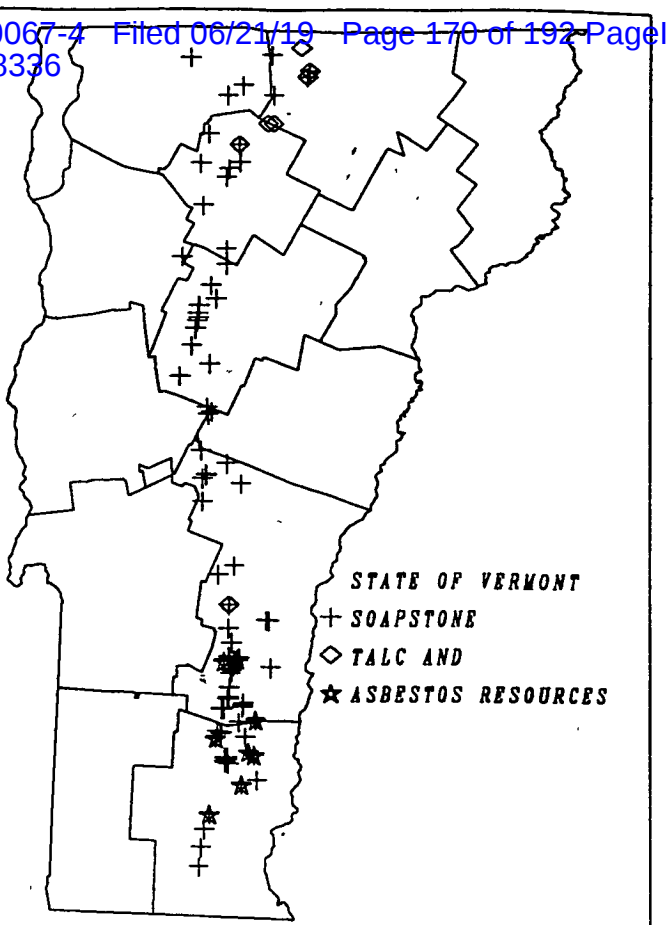
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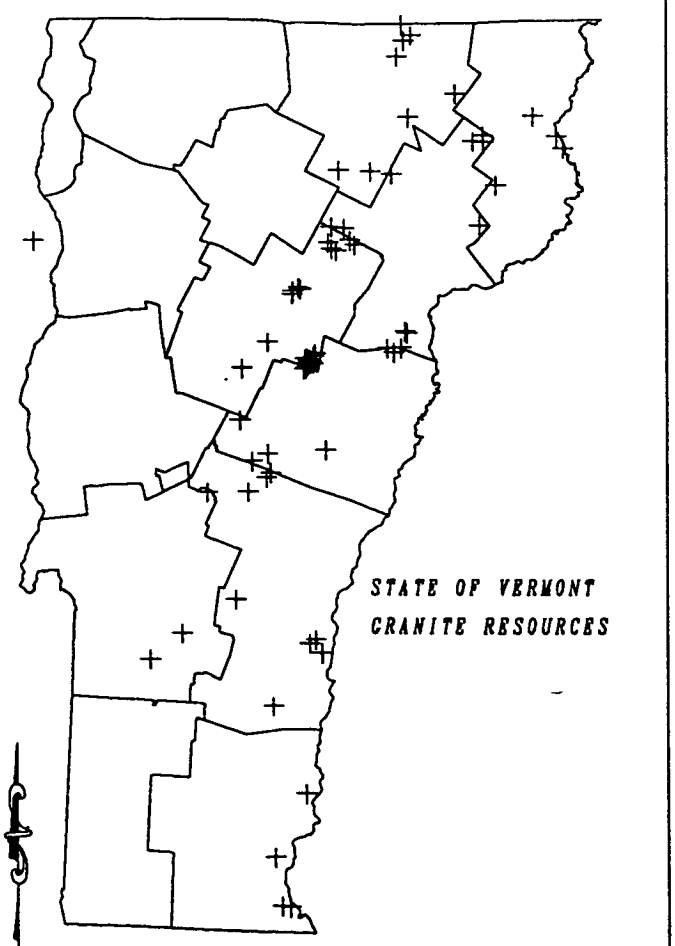
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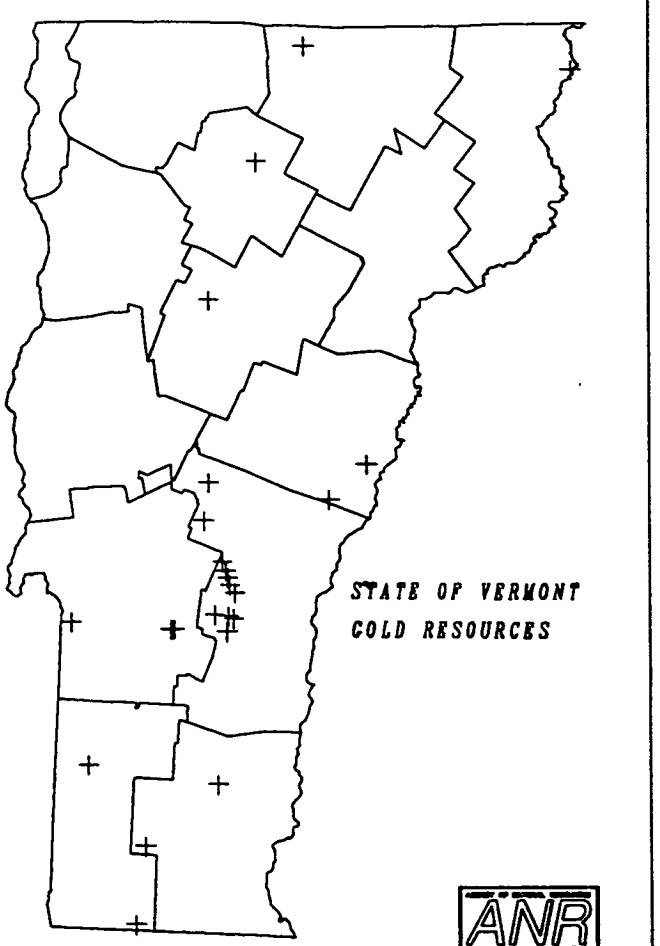
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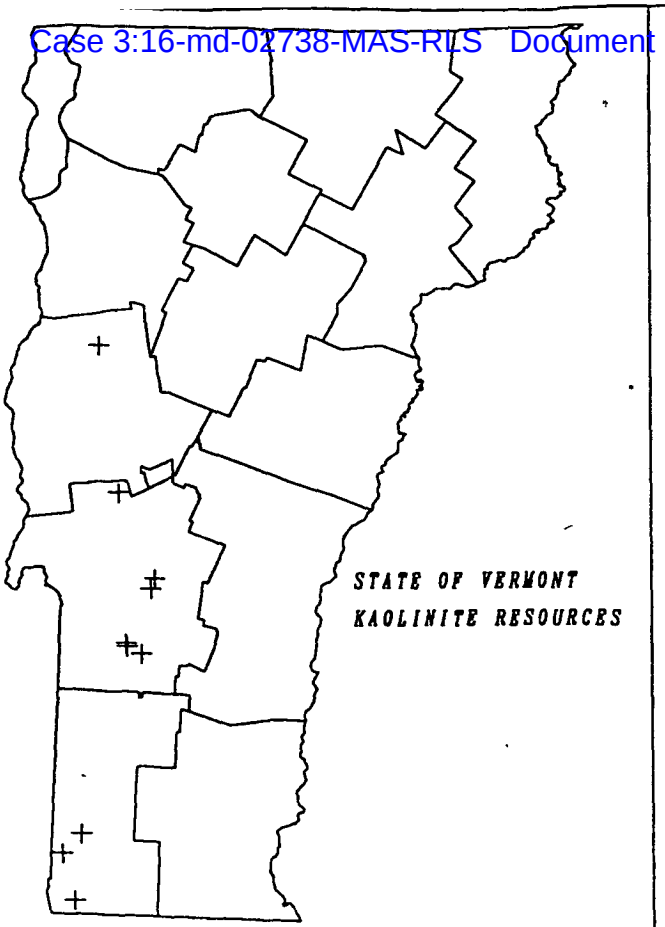

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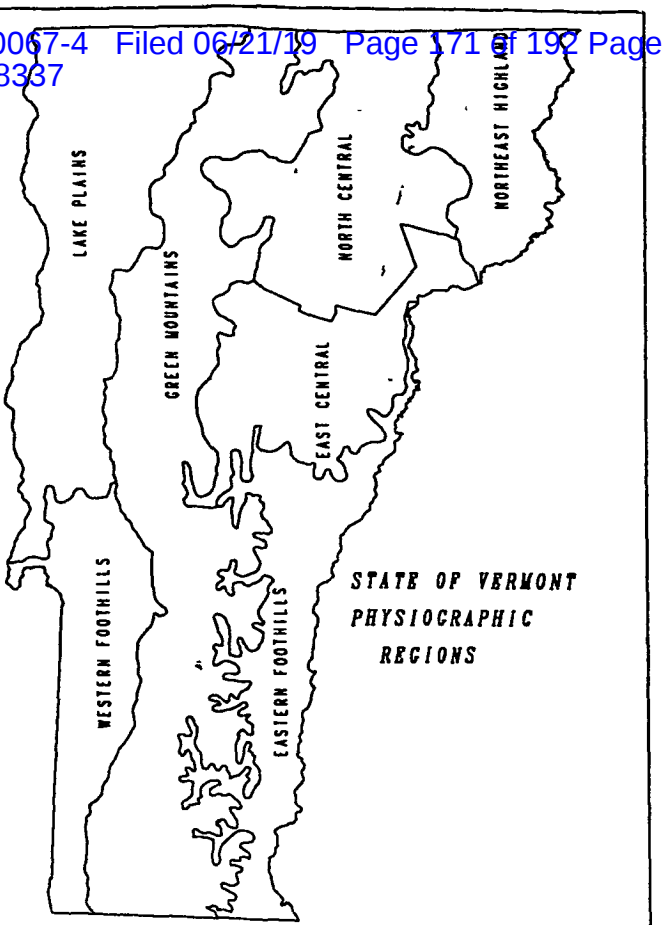

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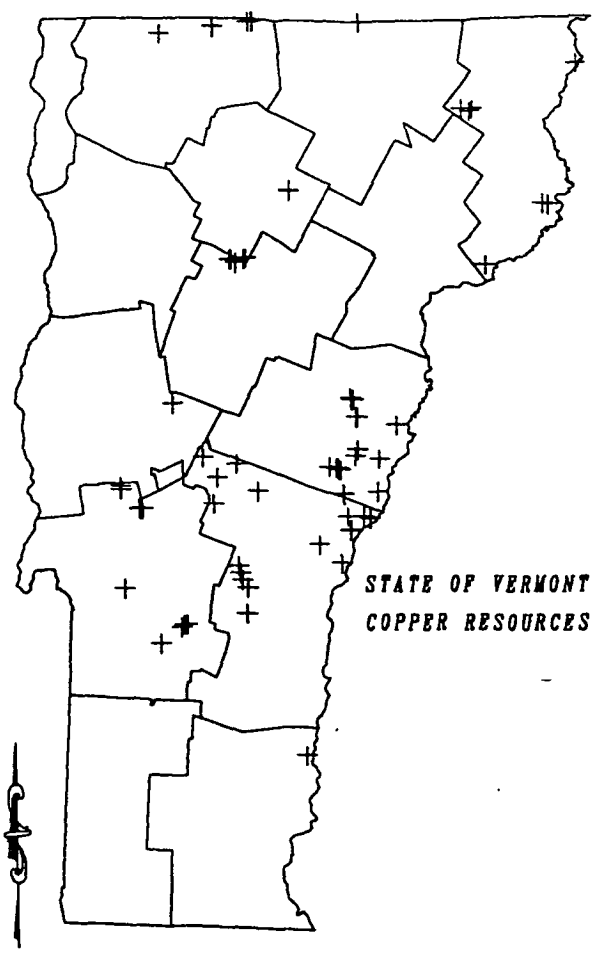

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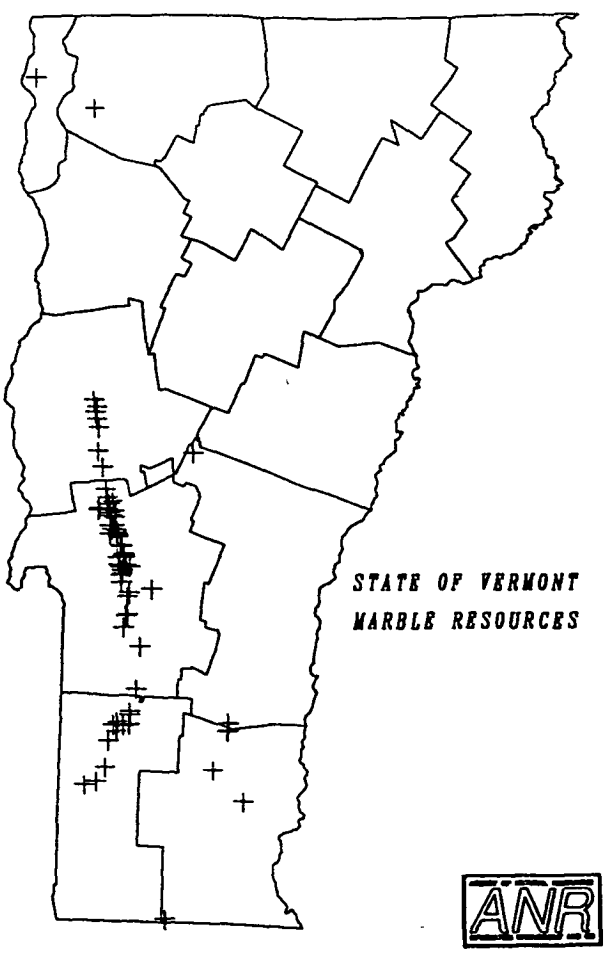

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Exhibit 23

Environmental Health Perspectives
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Amphibole Content of Cosmetic and Pharmaceutical Talcs

by A. M. Blount*

Pharmaceutical and cosmetic-grade talcs were examined for asbestiform amphibole content using a new density-optical method. Talcs under the Food and Drug Administration are not regulated as to asbestos content; however, all talcs were well below the level mandated by the Occupational Safety and Health Administration for industrial talcs. Only one was found to contain an amphibole particle size distribution typical of asbestos.

Introduction

In 1973 the Food and Drug Administration (FDA) proposed a regulation on the permissible asbestos content of talc (*1*). This regulation proposed to limit the amount of amphibole minerals to less than 0.1% and chrysotile to less than 0.01%. However, the optical microscopy method proposed was so complicated, lengthy, and subject to error that the proposed method was never finalized. Since then no final ruling has been issued.

The Occupational Safety and Health Administration, on the other hand, has been more rigorous and has instituted regulations despite the lack of methods to carry out the required measurements. One regulation, instituted in 1986, defines amphibole minerals as asbestos if the length to width ratio is 3:1 or greater. Because many nonfibrous cleavage fragments of amphibole minerals have a 3:1 aspect or greater and because there is no good evidence for adverse effects of these particles, a stay has been in affect on this part of the regulation (*2*). The second applicable regulation is the Hazard Communication Regulation (*3*), which applies to all chemicals used in the workplace. Specifically, it requires labeling of substances containing $>$ 1% of a chemical hazardous to health and $>$ 0.1% of a carcinogenic chemical.

Unfortunately, asbestos and amphiboles cannot be measured using currently developed methods to the level of 0.1% in the presence of talc. Some investigators have suggested that tremolite can be measured to that level by X-ray diffraction. But others have shown that the peak intensities vary between nonfibrous and fibrous tremolite (*4*) so that the 0.1% level of detection and measurement is doubtful except in cases where the sample has been spiked so that the exact nature of the tremolite is known. For anthophyllite there is little argument about the fact that detection cannot be made to 0.1%. However, the main problem with using X-ray diffraction for detection of amphibole minerals is that it gives no information about the shape of the particles, and shape is important in view of the uncertainity in the outcome of the asbestos regulation pertaining to nonfibrous amphiboles.

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The talcs that are pharmaceutical grade fall under the domain of the FDA and are therefore nonregulated in regard to fibrous mineral content. In the course of developing a technique to facilitate quantification of amphiboles in talc (*5*), pharmaceutical and high-grade talcs were examined. They were found to have very low amphibole content and, because of this, were extensively used in examining the lower limit of detection of the new method. The purpose of this paper is to describe the results of analyses for content and shape of amphibole mineral fragments in cosmetic and pharmaceutical talc powders of the United States.

Methods

The method proposed by the FDA in 1973 for analysis of talc was an optical procedure as described below (*1*):

> Weigh out 1 milligram of a representative portion of talc on each of two microscope slides. Mix the talc with a needle on one slide with a drop of 1.574 refractive index liquid, and then the other with 1.590 liquid, and place on each a square or rectangular cover glass sufficiently large so that the liquid will not run out from the edge (ca. 18 mm square) and will provide a uniform particle distribution. Fibers counted by this method should meet the following criteria: (i) Length to width ratio of 3 or greater (ii) length of 5 μm or greater (iii) width of 5 μm or less. Count and record the number of asbestos fibers in each 1 milligram as determined from a scan of both slides with a polarizing microscope at a magnification of approximately 400×. In the 1.574 refractive index liquid, chrysotile fibers with indices less than 1.574 in both extinction positions may be present: in the 1.590 refractive index liquid, the other five amphibole types of asbestos fibers with indices exceeding 1.590 in both extinction positions may be present. Check the extinction and sign of elongation for tentative identification. For specific identification of asbestos fibers, make additional mounts in appropriate refractive index liquids, and refer to the optical crystallographic data in the table. A count of not more than 1000 amphibole types of asbestos and not more than 100 chrysotile asbestos fibers per milligram-slide constitutes the maximum limit for the presence of these asbestos fibers in talc. These limits assure a purity of at least 99.9 percent free of amphibole types of asbestos fibers and at least 99.99 percent free of chrysotile asbestos fibers.

The problem with the proposed method is that talc flakes are often oriented vertically or at a sufficient angle that they appear to be needles and thus must be tested for refractive index (Fig. 1). A typical number of such particles is five per field of view. This

FIGURE 1. Talc flakes in 1.584 refractive index liquid. Note that there are particles in this field that have aspect ratios greater than 3:1. Width of view 0.13 mm.

means that some 20,000 particles would need to be examined in a typical case. In additon, chlorite is often present and when on edge must be examined in two extinction positions. This is clearly beyond what could be expected of any sane microscopist for a routine analysis. Since no other procedure has been developed as an alternative, a compromise has been to count 100 fields of view (FOV). In this way one need only examine about 500 particles in detail.

Because 500 particles is still a lengthy process, a more rapid and equally accurate method has been developed based on concentrating the amphibole particles by density difference. Figure 2 illustrates that there is a distinct break in density ranges between talcs and amphiboles. A heavy liquid of intermediate density is used, either Klein's (cadmium borotungstate) or Clerici's (thallium formate-malonate) solution. Experimentation showed that a heavy liquid of density 2.810 gives good separation even though values given in the literature and shown in Figure 2 would suggest that the density should be slightly higher. Because the density difference between particles and liquid is small, to get separation in a reasonable length of time a microcentrifuge is used with tubes containing 1.5 mL liquid. The height of the liquid column is, in this case, about 10 mm.

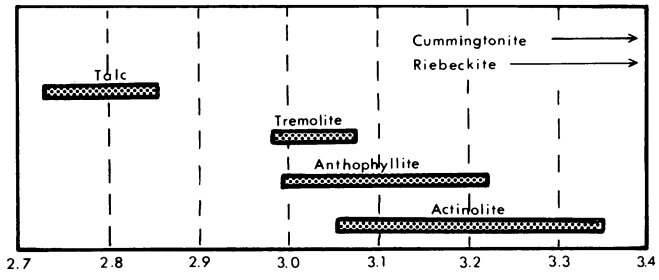

FIGURE 2. Specific gravities of talc and amphibole (6).

The general procedure involves weighing about 60 mg sample into a microcentrifuge tube and adding heavy liquid of density 2.810. After these are mixed, the tube with sample is placed in a vacuum for 3 min to remove the small bubbles adhering to the particles. After centrifuging the sample for 10 min at 7000 rpm, the heavy particles are removed from the bottom of the tube with a micropipette.

The counting of particles can be done either on a membrane filter (Nuclepore, 1.0 μm pore size) which has been placed on a microscope slide or as particles directly on the glass slide. In the first case, the heavy liquid with sample is forced through a membrane filter followed by distilled water to clean out the heavy liquid. The filter is then placed on a glass slide while wet. When dry, 1.584 refractive index liquid is placed on the filter followed by a cover glass. The photographs shown in this paper are of particles on filters.

The second case, particles directly on the microscope slide, requires transferring the heavy particles and some of the heavy liquid to a second centrifuge tube. Distilled water is added and the sample centrifuged. The liquid is pipetted off and more distilled water added. This is repeated several times to clean out the heavy liquid. Finally, the particles with several drops of water are transferred to a glass microscope slide. The advantage of this procedure is that any refractive index liquid can be used, whereas, in the former case, the refractive index is constrained by having to match the index of the membrane filter (either 1.584 or 1.625). The 1.584 value is good for analyzing amphiboles in talc, but the centrifuge method described has application to other mineral combinations, such as talc-quartz. With other combinations, refractive indices other than the two exhibited by the membrane filter may be more appropriate.

The particles are counted in 20 FOV. Being concentrated from 60 mg or more of sample, one will see more amphiboles than in 100 FOV using the old method. The number of amphibole particles per milligram (ppmg) is calculated:

$$\text{ppmg} = \text{amphibole particles/mg} = \frac{(\text{number of amphibole counted/number FOV counted}) \times \text{total number FOV}}{(\text{efficiency}) \times (\text{number of mg of sample})}$$

Efficiency of the spin-down is determined experimentally. For more details of the method see Blount (5).

Figure 3 illustrates the results obtained when testing the method using known mixtures. Because it is difficult to measure and mix in very small weights of amphibole, a sample containing 2% tremolite in talc was mixed with pure talc to make mixtures containing very low percentage values of tremolite. For example, sample A (Fig. 3) consisting of 0.06% tremolite was made by weighing 58.9 mg of pure talc with 1.7 mg of talc containing 2% tremolite (1.7 mg/60.6 mg $\times$ 2% = 0.06%). It is not necessary to make a homogeneous mixture since the entire sample was used in the experiment. Also, the talc containing amphibole was put in the tube second in order not to give the amphibole any "head-start" in sinking to the bottom.

The centrifuge method was also tested with a commercial talc. 100 FOV were counted in ten 1-mg samples according to the FDA procedure for amphibole. This was compared with 20 FOV counts on 60-mg centrifuge samples (Fig. 4). The agreement is quite good. The standard deviations were determined in two

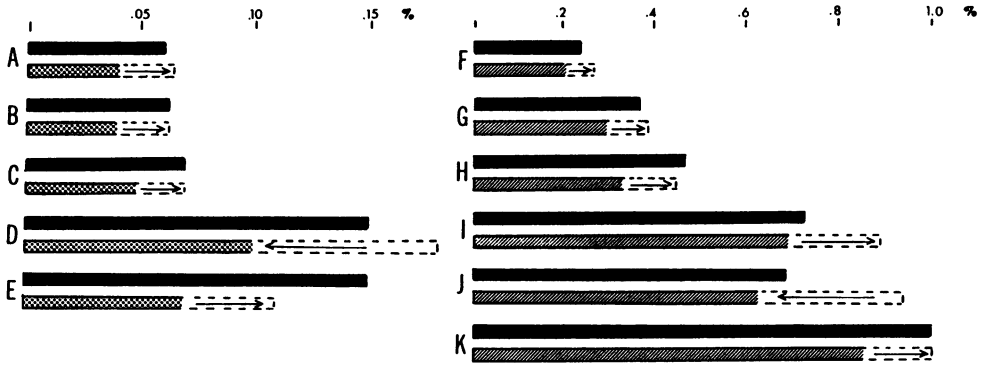

FIGURE 3. Percent tremolite in talc as determined by the centrifuge/optical method (shaded bars) compared with that actually present in experimental mixtures (black bars). The dashed part of the shaded bars indicates +2 SD (right arrow) or −2 SD (left arrow).

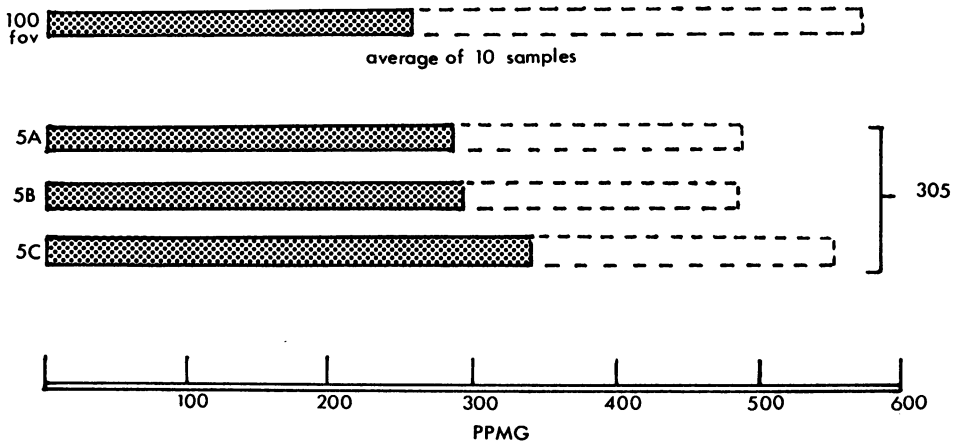

FIGURE 4. Comparison of traditional (100 FOV) count with centrifuge/optical count of same talc. The three lower bars indicate the values in particles/mg obtained by the centrifuge/optical method for three 60-mg samples. The top bar is the average of ten 100 FOV (traditional method). The dashed part of all the bars is +2 SD.

ways: for the traditional method by calculating in the usual way from multiple analyses and for the centrifuge method by means of the Poisson distribution from single counts. Standard deviations are high for the centrifuge method because of the very few particles counted. These could be decreased by making a larger count, but isnce the purpose of the study was to find a reasonably rapid method of monitoring amphibole content of talcs, larger counts were not generally made.

Results

High-grade talc products from five deposits in Montana, three in Vermont, and one each in North Carolina and Alabama were examined using the centrifuge/optical method. In addition, four talcs from outside the U.S. but available in the U.S. market were included in this study. Talcs from other districts in the U.S. were examined, but these talcs had grades with less stringent requirements and are not included in this report.

Results of particle counts are shown in Table 1. The FDA has equated 0.1% with 1000 particles per milligram. In order for amphibole particle content to be less than 0.1%, 20 or less particles must be observed in 20 FOV (*5*). Since all were well below this value, more extensive counts were not generally made.

It should be borne in mind that the 0.1% indicated is percent by count and not percent by weight or volume. The question of the validity of this relation has been considered (*5*). Briefly, the relation implies (1000 amphibole particles)/(1,000,000 total particles). Counts of total particles per milligram of talc have shown that 1 million particles per milligram of talc is a low value. Most show at least 2 to 3 times this number. The only exception was a baby powder with very large flakes which showed 0.4 to 0.8 million particles per milligram. It was not clear, however, whether this was a true value or due to the problem of counting where large, flakey particles could potentially hide other particles even in the most carefully prepared samples. Using 1000 particles/mg = 0.1% would, in most samples, give a percentage value on the high side and in this sense be a conservative answer.

The counts shown in Table 1 were made of regulatory fibers i.e., aspect ratio > 3:1. In some samples there were as many or more nonregulatory particles of amphibole as regulatory fibers. The shape of the amphibole varies greatly and seems to be highly characteristic of each deposit. In Table 1, the particles having aspect ratios less than 6:1 are designated cleavages and prismatic pieces. Those greater than 6:1 and less than 15:1 are labeled

Table 1. Counts of regulatory fibers in processed talcs.

Sample	Counts, particles/mg	SD	Particle shapes	Particles/FOV[a]
A	38	25	Cleavages	3/100
B	ND[b]			0/20
C	ND			0/20
D	< 25[c]		Cleavages	0/20
E	ND			0/20
F	ND			0/20
G	ND			0/20
H	17	17	Cleavages and needles	2/20
I	226	59	Needles and fibers	17/20[d]
	283	100	Needles and fibers	8/20
	291	98	Needles and fibers	9/20
	341	108	Needles and fibers	10/20
	102	51	Needles and fibers	3/20
J	25	14	Cleavages	1/20
	27	27	Cleavages	3/20
K	25	25	Cleavages	1/20
L	< 10[c]		Needles	0/20
M	39	21	Cleavages and fibers	4/20
N	25	17	Prismatic pieces	3/20
O	ND			0/20

[a]FOV, fields of view.
[b]ND, none detected.
[c]No particles seen during a 20 FOV count, but some particles could be seen during a random scan of the filter. Value shown is the lower limit of detection.
[d]Large sample used for this analysis (305 mg).

"needles." The remainder, which are greater than 15:1, are labeled "fibers." Whereas in many samples only a few particles were counted as shown in the right-hand column of Table 1, it should be remembered that even if only one particle was present in 20 FOV that about 300 were present on the slide. Because of the low interference by talc particles, these were seen so that it was easy to get a sense of the general particle shape.

The shape distribution of particles for several samples was determined. Figure 5 shows a photograph of a particle of tremolite in sample *I*. The particle is composed of fibrils. The length and width of 100 amphibole particles in this talc were measured. The resulting distribution of aspect ratios is shown in Figure 6. The results when compared with the aspect ratios determinded for tremolite asbestos with SEM by Campbell et al. (*7*) show sample *I* has a distribution similar to asbestos. Sample *M* was analyzed in the same way (Figs. 6 and 7). The graph of aspect ratio verses percent is compared with Campbell's results for nonfibrous tremolite. The similarity of the curves indicates that the tremolite in this talc is of the nonfibrous type.

Because the fractions produced by centrifuge are not generally pure after a single spin-down, a sample containing a variety of particle shapes was tested to see if the aspect ratio distribution results become biased in favor of larger, chunky grains (low aspect ratio) over small, long grains (high aspect ratio). The sample used contained 6.5% tremolite, a sufficient quantity that the traditional optical method could be used to compare with the centifuged sample. The resulting aspect ratio distribution curves (Fig. 8) do not show significant differences. With the traditional method, 69% of the amphibole particles have an aspect ratio of 3:1 or greater, whereas for the centrifuged samples the value is 64%, a variation which is not significant. The differences shown for 5:1 and 10:1 are probably due to the limited number of particles measured, in this test 100 particles in each sample.

Despite the similarity of the curves, the mean length and mean width of the amphibole particles measured using the centrifuge method are greater than those obtained using the traditional method (Table 2). Analysis of size distribution indicates that the proportion larger than 15 μm is greater in the centrifuged sample. This difference in dimension distribution does not appear, however, to affect the aspect ratio distribution. Other investigators have found that as particles increase in length, the aspect ratio shifts to higher values (*8,9*). This applies to both asbestos and nonasbestiform amphiboles, so presumably the effect of centrifuging down longer particles would be to force the aspect ratio distribution peak to higher values.

Discussion

The high-grade talc powders are uniformly low in amphibole content. Counts obtained were 0 to 341 particles/mg. Indeed, talc from some districts appears to be completely free of such minerals. In those containing amphibole minerals there are two distinct types: cleavage type and asbestos type. These two types show distinctly different aspect ratio distributions as demonstrated in Figure 6 (samples *I* and *M*). The aspect ratio difference probably accounts in a large part for the higher particle count per milligram of sample *I* compared with the others which show cleavage fragments. It is easy to see that the number of particles showing greater than 3:1 aspect ratio would be greater in the former case even if the total number of particles of amphibole were equal. This observation reinforces the original decision to count particles visually rather than attempting to use X-ray diffraction. It is not wise to try to convert information on dimensions to percent by weight or volume because a few very large particles can drastically affect the resulting value. Campbell et al. (*8*) discuss this in some detail.

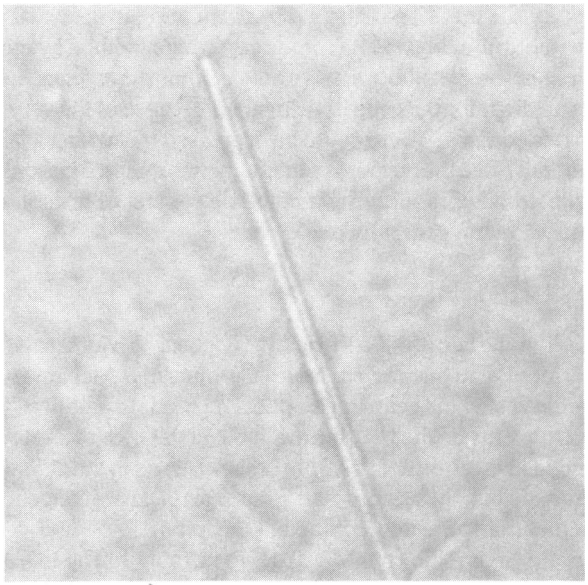

FIGURE 5. Particle of amphibole in centrifuged sample *I*. Width of view 0.07 mm and 1.584 refractive index liquid. Particle is on a membrane filter.

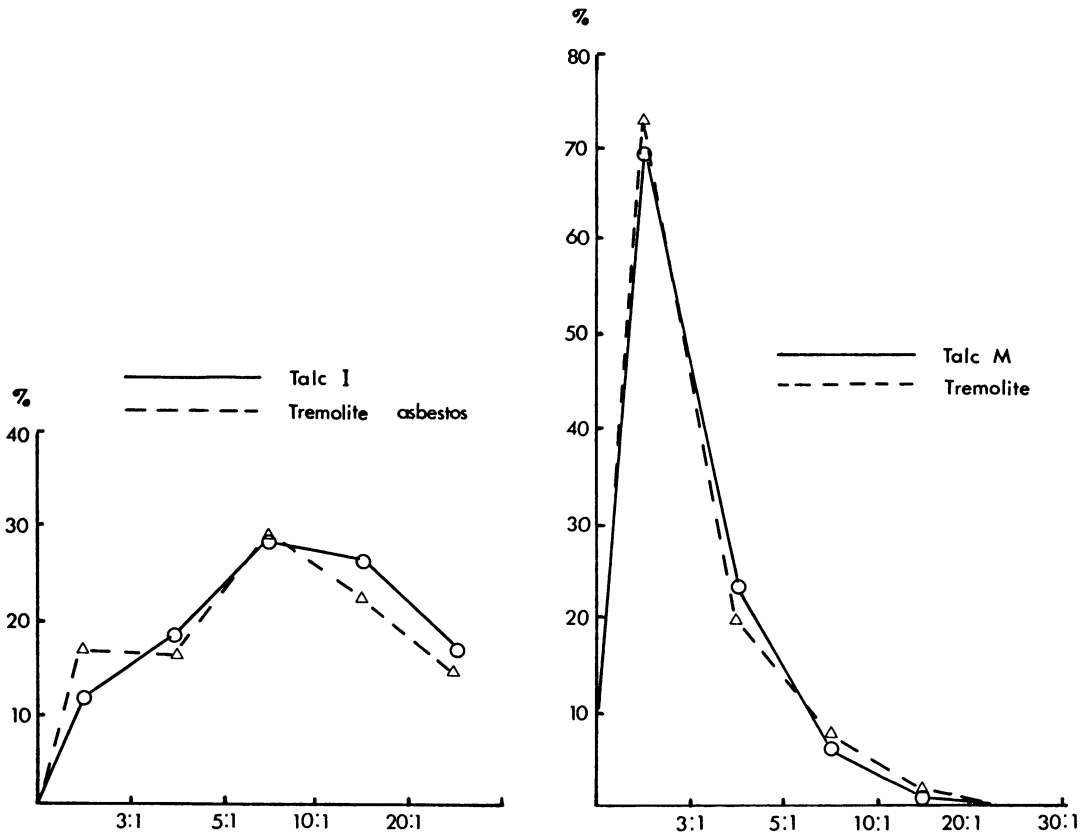

FIGURE 6. Percent amphiboles in each aspect ratio group for talc sample *I* (left) and *M* (right) compared with tremolite asbestos (*7*) and tremolite (nonasbestiform) (*7*).

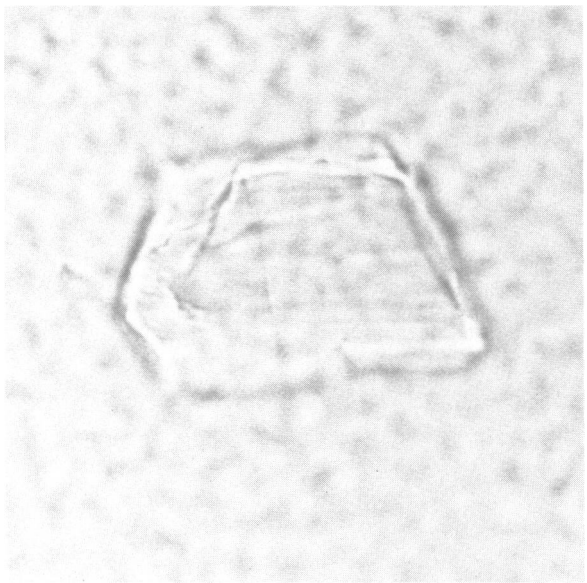

FIGURE 7. Particle of amphibole in centrifuged sample *M*. Width of view 0.07 mm and 1.584 refractive index liquid. Particle is on a membrane filter.

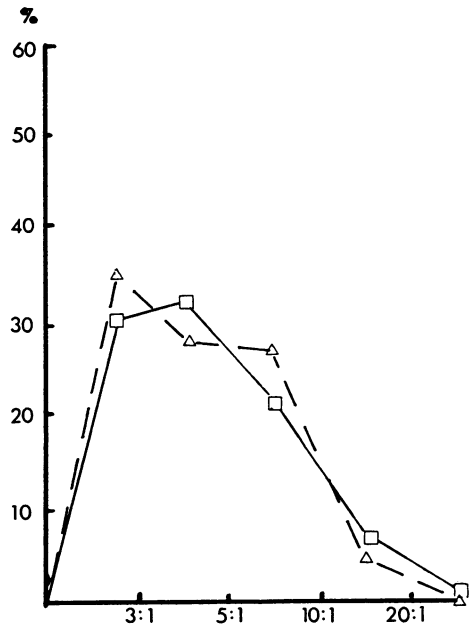

FIGURE 8. Percent amphiboles in each aspect group for a sample handled in two ways: solid line shows results using traditional method and dashed line shows results using centrifuge method. Dimensions of 100 particles measured for each curve.

Table 2. Summary of size and aspect ratio data used to construct Figure 8.

	Size, %		
Method	5–10 μm	10–15 μm	≥ 15 μm
Traditional	57	26	16
Centrifuge	33	27	38
	Mean length, μm	Mean width, μm	Mean aspect ratio, μm
Traditional	12.5	3.0	4.4
Centrifuge	17.5	4.7	4.6

Further, the results from this study demonstrate the utility of the centrifuge method not only for obtaining a count of particles, but also for obtaining information on the shape of particles in a population. It should be emphasized that the aspect ratio curves determined for samples *I* and *M* would have been virtually impossible to obtain using the FDA procedure. The determination would have required examining over 3000 FOV. As indicated previously, many talc flakes on edge appear to be fibers and must be examined during such a scan, making the whole job impossibly tedious.

Finally, even in those cases where one may wish to use the standard 100 FOV count, the centrifuge method offers a way to screen samples between those times when a more lengthy count is made, and it permits a double check of values so determined. In addition, the tendency to bring down a disproportional number of larger particles has the advantage that with true asbestiform amphiboles one generally sees some particles showing bundles of fibrils which removes any doubt about the nature of the amphibole.

REFERENCES

1. Food and Drug Administration. Asbestos Particles in Food and Drugs. Fed. Reg. 28: 27076–27081 (1973).
2. Occupational Safety and Health Administration. Occupational Exposure to Asbestos, Tremolite, Anthophyllite and Actinolite; Extension of Partial Stay and Amendment of Final Rule. Fed. Reg. 55: 50685–50687 (1990).
3. Occupational Safety and Health Administration. Hazard Communication; Final Rule. Fed. Reg. 25: 53280–53348 (1984).
4. McCrone, L. B. Analysis of Talc by X-Ray Diffraction and Polarized Light Microscopy. NIOSH Report, Contract 210-75-0063: 0–41, National Institute of Occupational Safety and Health, Cincinnati, OH, 1977.
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9. Wylie, A. G. Relationship between the growth habit of asbestos and the dimensions of asbestos fibers. Mining Engineer. 40: 1036–1040 (1988).

Exhibit 24

GMW

Alice M. Blount, Ph.D.
Mineralogist

April 23, 1998

M. Raymond Hatcher
MEHAFFY & WEBER
2615 Calder Avenue
P.O. Box 16
Beaumont, Texas 77704

Dear Mr. Hatcher:

According to your letter of March 31, 1998, I have written and enclosed a report on the occurrence, regulation and up-to-date scientific view of asbestos, amphiboles and "intermediate" fibers. I have also enclosed copies of my 1990 and 1991 papers, one of which I am sure that you already have. The 1991 paper was written because I became aware that it was a common opinion among industrial hygienists that industrial talcs were better than pharmaceutical and cosmetic talcs because there was a regulation for the former and not for the latter. I knew that this was not the case and wanted to set the record straight.

Although my papers report an improved method for analysis, the determinations for the sample labeled *I* (Johnson & Johnson's Vermont talc) have been done by the traditional methods as well (see Table 2, page 567 in the 1990 paper). As I told you, I believe that Johnson & Johnson's Vermont talc contains trace amounts of asbestos which are well below those specified by OSHA. It should be noted that the proposed FDA regulation, which was never finalized, also specified the same 0.1% limit for amphibole asbestos as OSHA.

I may be away for short periods during the coming weeks, but I do check for messages on my work phone at the number you have been using.

Sincerely yours,

Alice M. Blount

Alice M. Blount, Ph.D.

Box 3437
Rutland, VT 05701
Phone: 802-747-4857

e-mail: amblount@together.net

Environmental Health Perspectives
Vol. 94, pp. 225-230, 1991

Amphibole Content of Cosmetic and Pharmaceutical Talcs

by A. M. Blount*

Pharmaceutical and cosmetic-grade talcs were examined for asbestiform amphibole content using a new density-optical method. Talcs under the Food and Drug Administration are not regulated as to asbestos content; however, all talcs were well below the level mandated by the Occupational Safety and Health Administration for industrial talcs. Only one was found to contain an amphibole particle size distribution typical of asbestos.

Introduction

In 1973 the Food and Drug Administration (FDA) proposed a regulation on the permissible asbestos content of talc (*1*). This regulation proposed to limit the amount of amphibole minerals to less than 0.1% and chrysotile to less than 0.01%. However, the optical microscopy method proposed was so complicated, lengthy, and subject to error that the proposed method was never finalized. Since then no final ruling has been issued.

The Occupational Safety and Health Administration, on the other hand, has been more rigorous and has instituted regulations despite the lack of methods to carry out the required measurements. One regulation, instituted in 1986, defines amphibole minerals as asbestos if the length to width ratio is 3:1 or greater. Because many nonfibrous cleavage fragments of amphibole minerals have a 3:1 aspect or greater and because there is no good evidence for adverse effects of these particles, a stay has been in affect on this part of the regulation (*2*). The second applicable regulation is the Hazard Communication Regulation (*3*), which applies to all chemicals used in the workplace. Specifically, it requires labeling of substances containing > 1% of a chemical hazardous to health and > 0.1% of a carcinogenic chemical.

Unfortunately, asbestos and amphiboles cannot be measured using currently developed methods to the level of 0.1% in the presence of talc. Some investigators have suggested that tremolite can be measured to that level by X-ray diffraction. But others have shown that the peak intensities vary between nonfibrous and fibrous tremolite (*4*) so that the 0.1% level of detection and measurement is doubtful except in cases where the sample has been spiked so that the exact nature of the tremolite is known. For anthophyllite there is little argument about the fact that detection cannot be made to 0.1%. However, the main problem with using X-ray diffraction for detection of amphibole minerals is that it gives no information about the shape of the particles, and shape is important in view of the uncertainity in the outcome of the asbestos regulation pertaining to nonfibrous amphiboles.

*Geology Department, Rutgers University, Newark, [redacted]02.

The talcs that are pharmaceutical grade fall under the domain of the FDA and are therefore nonregulated in regard to fibrous mineral content. In the course of developing a technique to facilitate quantification of amphiboles in talc (*5*), pharmaceutical and high-grade talcs were examined. They were found to have very low amphibole content and, because of this, were extensively used in examining the lower limit of detection of the new method. The purpose of this paper is to describe the results of analyses for content and shape of amphibole mineral fragments in cosmetic and pharmaceutical talc powders of the United States.

Methods

The method proposed by the FDA in 1973 for analysis of talc was an optical procedure as described below (*1*):

> Weigh out 1 milligram of a representative portion of talc on each of two microscope slides. Mix the talc with a needle on one slide with a drop of 1.574 refractive index liquid, and then the other with 1.590 liquid, and place on each a square or rectangular cover glass sufficiently large so that the liquid will not run out from the edge (ca. 18 mm square) and will provide a uniform particle distribution. Fibers counted by this method should meet the following criteria: (i) Length to width ratio of 3 or greater (ii) length of 5 μm or greater (iii) width of 5 μm or less. Count and record the number of asbestos fibers in each 1 milligram as determined from a scan of both slides with a polarizing microscope at a magnification of approximately 400×. In the 1.574 refractive index liquid, chrysotile fibers with indices less than 1.574 in both extinction positions may be present; in the 1.590 refractive index liquid, the other five amphibole types of asbestos fibers with indices exceeding 1.590 in both extinction positions may be present. Check the extinction and sign of elongation for tentative identification. For specific identification of asbestos fibers, make additional mounts in appropriate refractive index liquids, and refer to the optical crystallographic data in the table. A count of not more than 1000 amphibole types of asbestos and not more than 100 chrysotile asbestos fibers per milligram-slide constitutes the maximum limit for the presence of these asbestos fibers in talc. These limits assure a purity of at least 99.9 percent free of amphibole types of asbestos fibers and at least 99.99 percent free of chrysotile asbestos fibers.

The problem with the proposed method is that talc flakes are often oriented vertically or at a sufficient angle that they appear to be needles and thus must be tested for refractive index (Fig. 1). A typical number of such particles is five per field of view. This

FIGURE 1. Talc flakes in 1.584 refractive index liquid. Note that there are particles in this field that have aspect ratios greater than 3:1. Width of view 0.13 mm.

means that some 20,000 particles would need to be examined in a typical case. In additon, chlorite is often present and when on edge must be examined in two extinction positions. This is clearly beyond what could be expected of any sane microscopist for a routine analysis. Since no other procedure has been developed as an alternative, a compromise has been to count 100 fields of view (FOV). In this way one need only examine about 500 particles in detail.

Because 500 particles is still a lengthy process, a more rapid and equally accurate method has been developed based on concentrating the amphibole particles by density difference. Figure 2 illustrates that there is a distinct break in density ranges between talcs and amphiboles. A heavy liquid of intermediate density is used, either Klein's (cadmium borotungstate) or Clerici's (thallium formate-malonate) solution. Experimentation showed that a heavy liquid of density 2.810 gives good separation even though values given in the literature and shown in Figure 2 would suggest that the density should be slightly higher. Because the density difference between particles and liquid is small, to get separation in a reasonable length of time a microcentrifuge is used with tubes containing 1.5 mL liquid. The height of the liquid column is, in this case, about 10 mm.

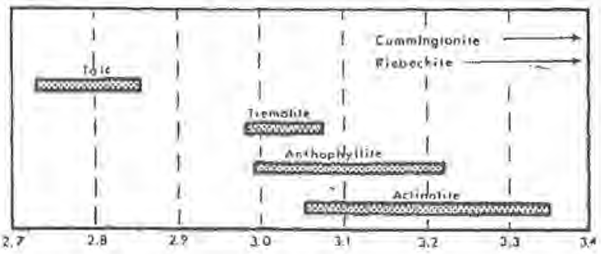

FIGURE 2. Specific gravities of talc and amphibole (6).

The general procedure involves weighing about 60 mg sample into a microcentrifuge tube and adding heavy liquid of density 2.810. After these are mixed, the tube with sample is placed in a vacuum for 3 min to remove the small bubbles adhering to the particles. After centrifuging the sample for 10 min at 7000 rpm, the heavy particles are removed from the bottom of the tube with a micropipette.

The counting of particles can be done either on a membrane filter (Nuclepore, 1.0 μm pore size) which has been placed on a microscope slide or as particles directly on the glass slide. In the first case, the heavy liquid with sample is forced through a membrane filter followed by distilled water to clean out the heavy liquid. The filter is then placed on a glass slide while wet. When dry, 1.584 refractive index liquid is placed on the filter followed by a cover glass. The photographs shown in this paper are of particles on filters.

The second case, particles directly on the microscope slide, requires transferring the heavy particles and some of the heavy liquid to a second centrifuge tube. Distilled water is added and the sample centrifuged. The liquid is pipetted off and more distilled water added. This is repeated several times to clean out the heavy liquid. Finally, the particles with several drops of water are transferred to a glass microscope slide. The advantage of this procedure is that any refractive index liquid can be used, whereas, in the former case, the refractive index is constrained by having to match the index of the membrane filter (either 1.584 or 1.625). The 1.584 value is good for analyzing amphiboles in talc, but the centrifuge method described has application to other mineral combinations, such as talc-quartz. With other combinations, refractive indices other than the two exhibited by the membrane filter may be more appropriate.

The particles are counted in 20 FOV. Being concentrated from 60 mg or more of sample, one will see more amphiboles than in 100 FOV using the old method. The number of amphibole particles per milligram (ppmg) is calculated:

$$\text{ppmg} = \text{amphibole particles/mg} = \frac{(\text{number of amphibole counted/number FOV counted}) \times \text{total number FOV}}{(\text{efficiency}) \times (\text{number of mg of sample})}$$

Efficiency of the spin-down is determined experimentally. For more details of the method see Blount (5).

Figure 3 illustrates the results obtained when testing the method using known mixtures. Because it is difficult to measure and mix in very small weights of amphibole, a sample containing 2% tremolite in talc was mixed with pure talc to make mixtures containing very low percentage values of tremolite. For example, sample A (Fig. 3) consisting of 0.06% tremolite was made by weighing 58.9 mg of pure talc with 1.7 mg of talc containing 2% tremolite (1.7 mg/60.6 mg × 2% = 0.06%). It is not necessary to make a homogeneous mixture since the entire sample was used in the experiment. Also, the talc containing amphibole was put in the tube second in order not to give the amphibole any "head-start" in sinking to the bottom.

The centrifuge method was also tested with a commercial talc. 100 FOV were counted in ten 1-mg samples according to the FDA procedure for amphibole. This was compared with 20 FOV counts on 60-mg centrifuge samples (Fig. 4). The agreement is quite good. The standard deviations were determined in two

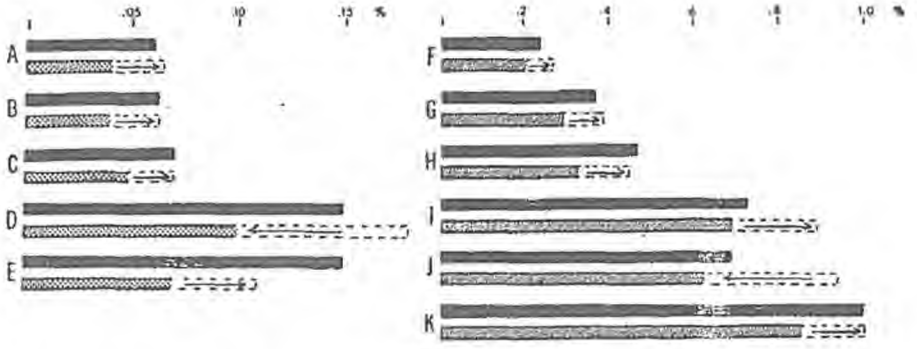

FIGURE 3. Percent tremolite in talc as determined by the centrifuge/optical method (shaded bars) compared with that actually present in experimental mixtures (black bars). The dashed part of the shaded bars indicates +2 SD (right arrow) or −2 SD (left arrow).

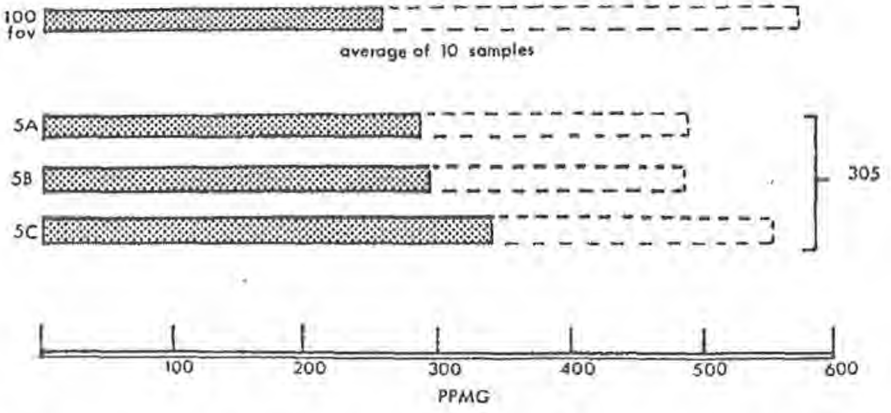

FIGURE 4. Comparison of traditional (100 FOV) count with centrifuge/optical count of same talc. The three lower bars indicate the values in particles/mg obtained by the centrifuge/optical method for three 60-mg samples. The top bar is the average of ten 100 FOV (traditional method). The dashed part of all the bars is +2 SD.

ways: for the traditional method by calculating in the usual way from multiple analyses and for the centrifuge method by means of the Poisson distribution from single counts. Standard deviations are high for the centrifuge method because of the very few particles counted. These could be decreased by making a larger count, but isnce the purpose of the study was to find a reasonably rapid method of monitoring amphibole content of talcs, larger counts were not generally made.

Results

High-grade talc products from five deposits in Montana, three in Vermont, and one each in North Carolina and Alabama were examined using the centrifuge/optical method. In addition, four talcs from outside the U.S. but available in the U.S. market were included in this study. Talcs from other districts in the U.S. were examined, but these talcs had grades with less stringent requirements and are not included in this report.

Results of particle counts are shown in Table 1. The FDA has equated 0.1% with 1000 particles per milligram. In order for amphibole particle content to be less than 0.1%, 20 or less particles must be observed in 20 FOV (5). Since all were well below this value, more extensive counts were not generally made.

It should be borne in mind that the 0.1% indicated is percent by count and not percent by weight or volume. The question of the validity of this relation has been considered (5). Briefly, the relation implies (1000 amphibole particles)/(1,000,000 total particles). Counts of total particles per milligram of talc have shown that 1 million particles per milligram of talc is a low value. Most show at least 2 to 3 times this number. The only exception was a baby powder with very large flakes which showed 0.4 to 0.8 million particles per milligram. It was not clear, however, whether this was a true value or due to the problem of counting where large, flakey particles could potentially hide other particles even in the most carefully prepared samples. Using 1000 particles/mg = 0.1% would, in most samples, give a percentage value on the high side and in this sense be a conservative answer.

The counts shown in Table 1 were made of regulatory fibers i.e., aspect ratio > 3:1. In some samples there were as many or more nonregulatory particles of amphibole as regulatory fibers. The shape of the amphibole varies greatly and seems to be highly characteristic of each deposit. In Table 1, the particles having aspect ratios less than 6:1 are designated cleavages and prismatic pieces. Those greater than 6:1 and less than 15:1 are labeled

Table 1. Counts of regulatory fibers in processed talcs.

Sample	Counts, particles/mg	SD	Particle shapes	Particles/FOV[a]
A	38	25	Cleavages	3/100
B	ND[b]			0/20
C	ND			0/20
D	< 25[c]		Cleavages	0/20
E	ND			0/20
F	ND			0/20
G	ND			0/20
H	17	17	Cleavages and needles	2/20
I	226	59	Needles and fibers	17/20[d]
	283	100	Needles and fibers	8/20
	291	98	Needles and fibers	9/20
	341	108	Needles and fibers	10/20
	102	51	Needles and fibers	3/20
J	25	14	Cleavages	1/20
	27	27	Cleavages	3/20
K	25	25	Cleavages	1/20
L	< 10[c]		Needles	0/20
M	39	21	Cleavages and fibers	4/20
N	25	17	Prismatic pieces	3/20
O	ND			0/20

[a]FOV, fields of view.
[b]ND, none detected.
[c]No particles seen during a 20 FOV count, but some particles could be seen during a random scan of the filter. Value shown is the lower limit of detection.
[d]Large sample used for this analysis (305 mg).

"needles." The remainder, which are greater than 15:1, are labeled "fibers." Whereas in many samples only a few particles were counted as shown in the right-hand column of Table 1, it should be remembered that even if only one particle was present in 20 FOV that about 300 were present on the slide. Because of the low interference by talc particles, these were seen so that it was easy to get a sense of the general particle shape.

The shape distribution of particles for several samples was determined. Figure 5 shows a photograph of a particle of tremolite in sample *I*. The particle is composed of fibrils. The length and width of 100 amphibole particles in this talc were measured. The resulting distribution of aspect ratios is shown in Figure 6. The results when compared with the aspect ratios determinded for tremolite asbestos with SEM by Campbell et al. (*7*) show sample *I* has a distribution similar to asbestos. Sample *M* was analyzed in the same way (Figs. 6 and 7). The graph of aspect ratio verses percent is compared with Campbell's results for nonfibrous tremolite. The similarity of the curves indicates that the tremolite in this talc is of the nonfibrous type.

Because the fractions produced by centrifuge are not generally pure after a single spin-down, a sample containing a variety of particle shapes was tested to see if the aspect ratio distribution results become biased in favor of larger, chunky grains (low aspect ratio) over small, long grains (high aspect ratio). The sample used contained 6.5% tremolite, a sufficient quantity that the traditional optical method could be used to compare with the centifuged sample. The resulting aspect ratio distribution curves (Fig. 8) do not show significant differences. With the traditional method, 69% of the amphibole particles have an aspect ratio of 3:1 or greater, whereas for the centrifuged samples the value is 64%, a variation which is not significant. The differences shown for 5:1 and 10:1 are probably due to the limited number of particles measured, in this test 100 particles in each sample.

Despite the similarity of the curves, the mean length and mean width of the amphibole particles measured using the centrifuge method are greater than those obtained using the traditional method (Table 2). Analysis of size distribution indicates that the proportion larger than 15 μm is greater in the centrifuged sample. This difference in dimension distribution does not appear, however, to affect the aspect ratio distribution. Other investigators have found that as particles increase in length, the aspect ratio shifts to higher values (*8, 9*). This applies to both asbestos and nonasbestiform amphiboles, so presumably the effect of centrifuging down longer particles would be to force the aspect ratio distribution peak to higher values.

Discussion

The high-grade talc powders are uniformly low in amphibole content. Counts obtained were 0 to 341 particles/mg. Indeed, talc from some districts appears to be completely free of such minerals. In those containing amphibole minerals there are two distinct types: cleavage type and asbestos type. These two types show distinctly different aspect ratio distributions as demonstrated in Figure 6 (samples *I* and *M*). The aspect ratio difference probably accounts in a large part for the higher particle count per milligram of sample *I* compared with the others which show cleavage fragments. It is easy to see that the number of particles showing greater than 3:1 aspect ratio would be greater in the former case even if the total number of particles of amphibole were equal. This observation reinforces the original decision to count particles visually rather than attempting to use X-ray diffraction. It is not wise to try to convert information on dimensions to percent by weight or volume because a few very large particles can drastically affect the resulting value. Campbell et al. (*8*) discuss this in some detail.

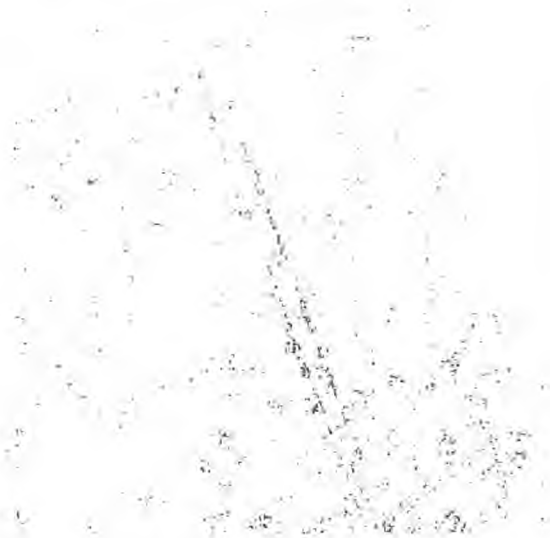

FIGURE 5. Particle of amphibole in centrifuged sample *I*. Width of view 0.07 mm and 1.584 refractive index liquid. Particle is on a membrane filter.

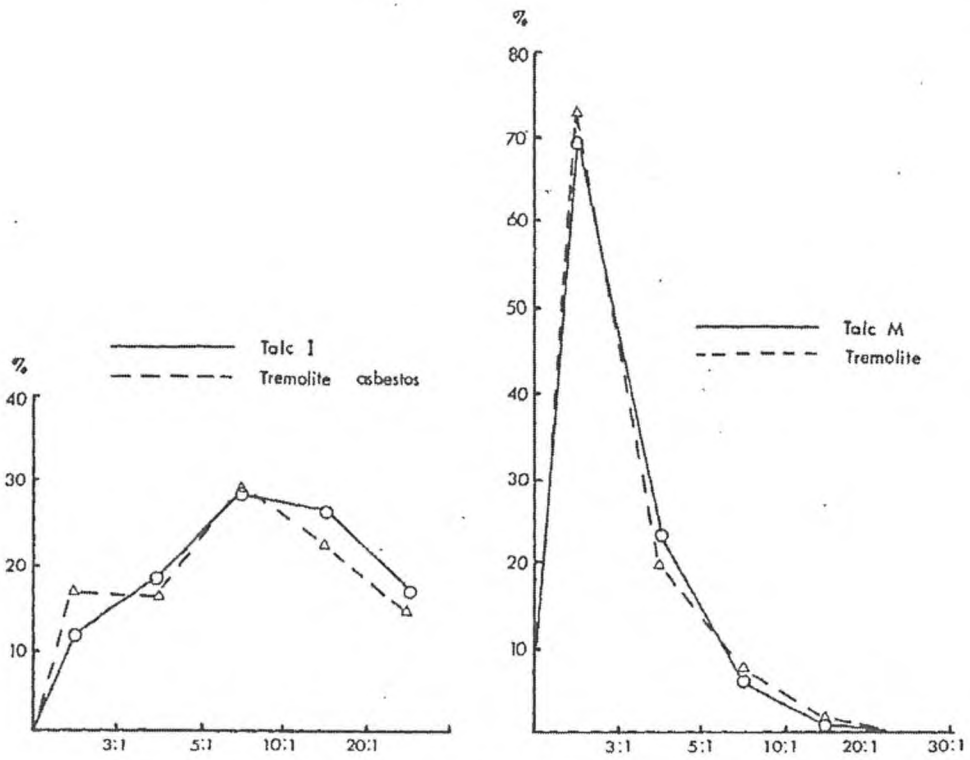

FIGURE 6. Percent amphiboles in each aspect ratio group for talc sample *I* (left) and *M* (right) compared with tremolite asbestos (*7*) and tremolite (nonasbestiform) (*7*).

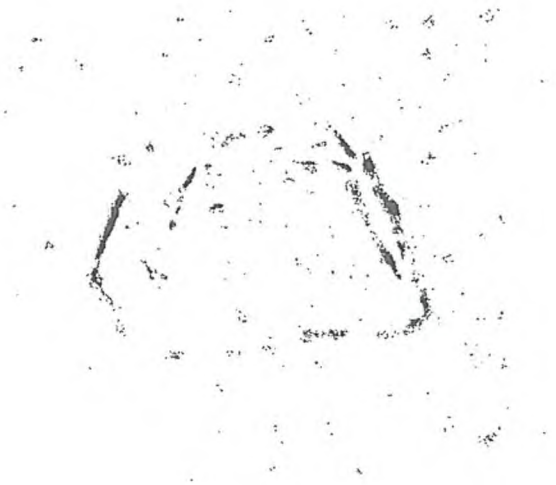

FIGURE 7. Particle of amphibole in centrifuged sample *M*. Width of view 0.07 mm and 1.584 refractive index liquid. Particle is on a membrane filter.

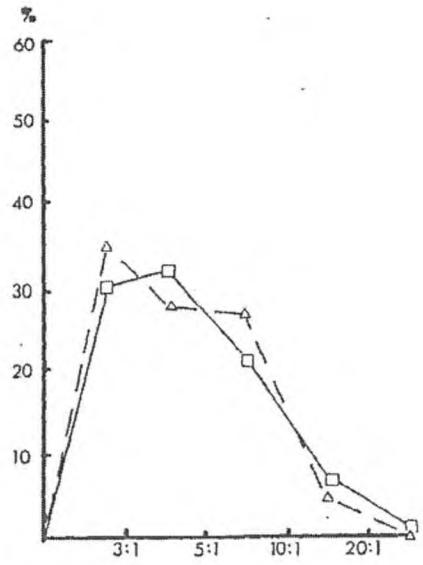

FIGURE 8. Percent amphiboles in each aspect group for a sample handled in two ways: solid line shows results using traditional method and dashed line shows results using centrifuge method. Dimensions of 100 particles measured for each curve.

Table 2. Summary of size and aspect ratio data used to construct Figure 8.

	Size, %		
Method	5–10 μm	10–15 μm	≥ 15 μm
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9. Wylie, A. G. Relationship between the growth habit of asbestos and the dimensions of asbestos fibers. Mining Engineer. 40: 1036–1040 (1988).

A – Italian

B – Montana – Willow Creek

C – Montana (Beaverhead?) Pfizer

D – North Carolina

E – Alabama

F – Montana – Willow Creek

G – Montana Floated at Alabama (Pfizer) Belmont?

H – Italian

I – Windsor – J&J JBP

J, K, L, M – other VT depositions – M = Troy

N – Timmins Ontario – Steetly

O – Willow Creek – Montana Talc Co.

Exhibit 25

IN THE CIRCUIT COURT OF THE CITY OF ST. LOUIS
STATE OF MISSOURI

GAIL LUCILLE INGHAM and ROBERT INGHAM, et al.,	)	
Plaintiffs,	)	Case Number: 1522-CC10417-01
v.	)	
JOHNSON & JOHNSON, et al.,	)	
Defendants.	)	

FRIDAY, APRIL 13, 2018

– – –

Videotaped deposition of Alice M. Blount, Ph.D., held at the Best Western Hotel, 5 Best Western Place, Rutland, Vermont, commencing at 9:23 a.m., on the above date, before Carrie A. Campbell, Registered Diplomate Reporter, Certified Realtime Reporter, Illinois, California & Texas Certified Shorthand Reporter, Missouri & Kansas Certified Court Reporter.

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A. Yeah, that's not southern.
Q. Okay. That's not southern. Fair enough.
Dr. Blount, I want to ask you two important questions, and then we're going to dig into some information behind your answers.
Okay?
A. Uh-huh.
Q. The first question is this: Have you tested Johnson & Johnson baby powder for asbestos?
A. Yes.
Q. And then the important follow-up question: Does Johnson & Johnson baby powder, or did it when you tested it, have asbestos?
MR. DUBIN: Object to form.
THE WITNESS: Yes.
QUESTIONS BY MR. LANIER:
Q. Now, because of your answers to those questions, I want to ask you some background information so the jury knows who you are, and I want to ask you a little bit about the asbestos you found.

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You are what we've listed in this trial as a fact witness, so I'm not asking you to give me expert opinions outside of; just what you did and what you understand from your actual actions.
Okay?
A. Uh-huh.
Q. All right. So let's start out with who you are.
Now, I've had the benefit -- and we'll get into this in a little more detail later. I've had the benefit of meeting with you I think on about three different times. Three or four; is that right?
A. That's about right.
Q. I know that on two of three of those times we talked for about 20 or 30 minutes about this information over a cup of coffee --
A. Yes.
Q. -- at the bakery.
A. (Witness nods head.)
Q. And then last night we had dinner with your husband, Jack, at a

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delightful place, though I don't really think we talked about this at all.
A. No.
Q. All right. Dr. Blount, I want the jury to get the benefit of knowing your background, so let's start out talking about that a little bit.
Where did you grow up as a girl?
A. I grew up in Carbondale, Illinois.
Q. Carbondale, Illinois. That's on the other side of the Mississippi River from St. Louis where we're trying this case.
A. Not that far. We used to go into St. Louis all the time.
Q. That was the big city for you, maybe.
A. Yes, close.
Q. Carbondale, Illinois.
And you brought with you some papers today, and among those papers was a résumé that you did when you were trying to -- or when you were getting ready for a position or something at Rutgers, I think.

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Is that right?
A. Yes, Rutgers in Newark, Newark branch of Rutgers.
Q. Okay. We'll get to you and Rutgers in a minute.
By the way, just for grins, tell the jury where you live now and why we're having to do this by a deposition instead of you just driving in from Carbondale.
Where are we today?
A. We're in Rutland, Vermont.
Q. Rutland, Vermont.
And I know you still do some consulting work, but basically --
A. We came up here because I had a job up here.
Q. All right. Very good.
And then your husband's retired, I think?
A. Yes.
Q. All right. So let's just grab a couple of things off of your résumé to make sure that we've got everything right.
This is a résumé that you did

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the background.
A. Yes.
Q. Is this the one where you --
A. You put a filter in sort of the middle part of the microscope, and it's the color of the -- if it's yellow, then we know what -- you know, we know it's an asbestos fiber. If it was blue, then it wouldn't be. So that's why we have these colors here.
Q. Ah, so that's what tells you that that sphere-looking thing is asbestos?
A. (Witness nods head.)
Q. Okay.
A. That's why we put the color in there.
Q. All right. By the way, where did you get this asbestos from that's in these pictures?
A. From Johnson & Johnson baby powder.
Q. All right. Now, you actually taught the graduate students how to use these microscopes and do this work?
A. Yes, we did -- yes, I taught that.

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Q. Okay. And that's in addition to supervising graduate thesis research and teaching undergraduate courses as well?
A. Yes.
Q. And did you also consult with several major industrial minerals companies doing this very kind of work --
A. Yeah.
Q. -- identifying and counting asbestos-type materials in industrial mineral products?
Is that you?
A. Yes, that's me.
Q. All right. Well, we've got a list here of your publications at the time, your references. We'll set that aside for a moment, though I did get two of your publications from you.
I got the "Amphibole Content of Cosmetic and Pharmaceutical Talcs" you published in 1991; is that correct?
A. Yeah, it looks like it.
Q. And I made you sign it. I got an autographed copy, didn't I?
A. That's right, you did.

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Q. And I've also got your paper from 1983 that I had kind of an original set of, and I got you to sign that one as well, didn't I?
A. You did.
Q. All right. Well, I'd like to make sure that -- so on your background we've got your work at Rutgers, where you've got a Ph.D. in mineralogy and geology; is that right?
A. Yes.
Q. I can't spell mineralogy. Mineralogy.
It's something like that. I can do geology. Geology.
Okay. And then you went to Rutgers where you did some teaching and research, and then you've also done consulting for companies, all to -- not all, but including to identify asbestos.
Is this fair?
A. That's fair.
Q. All right. Now, I want to change to a new subject here, so with that being it, you've got your microscope.

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Where did you get the asbestos from that you've put -- that we've seen here in Exhibit 5 and 6?
You said you got it from the Johnson & Johnson baby powder, but where did the baby powder come from?
A. Where the baby powder -- I bought it off the shelf, I think in New Jersey, but I'm not --
Q. So you just bought it off the shelf?
A. Yeah.
Q. Very good.
You've also got these two pictures that I've marked as Exhibit 2 and 3. And Exhibit 2, it looks like the -- is this sphere-looking thing still the fiber?
A. Yes.
Q. Okay. In one picture it's yellow, and in the other picture it's blue and it's going the opposite direction.
How is that? Can you explain that to me?
A. Well, it's blue because it's oriented in the opposite direction. It will

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type this up as well. And uh-huhs, even with the great Carrie Campbell, can sometimes read like huh-uhs, so I need to make sure I've got a yes or no out loud, if you don't mind.
A. Okay. Yes.
Q. All right. So that is -- the yellow like that is the asbestos; is that right?
A. That shows us, yes, that -- because of the -- the light goes through at different rates going this way or this way, so that makes a difference when you put this filter in. You can tell the difference between the fast ray and the slow ray.
Q. Super. Super.
Now, you wrote up papers, and I know in your 1991 paper you actually talked about the fact that there was asbestos in the baby powder. It looks to me like you -- and the jury will have a chance to read this in more detail and see that Sample I, talc Sample I, is actually Johnson & Johnson baby powder. And nobody's fussing that. The company's got those records and --
MR. DUBIN: Object to form.

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QUESTIONS BY MR. LANIER:
Q. -- and everything else. So just accept that with me right now.
"Percent amphiboles in each aspect ratio group for talc Sample I left and M right compared with tremolite asbestos and tremolite non-asbestiform."
So let me ask you as we zoom in on the Johnson & Johnson. Is the asbestos that you found a tremolite asbestos?
A. Yes.
Q. And you can see this form of it? Is that the dotted line?
A. Yes, that's what it -- what the -- what they found out about it.
Q. And if we look at your counts in these talcs on an earlier page and we look at that Sample I, which I think the record shows is the Johnson & Johnson baby powder --
MR. DUBIN: Objection. Form.
QUESTIONS BY MR. LANIER:
Q. -- these particles per milligram, is that how many particles you were finding of the asbestos?
A. That's what it's finding on the

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slides, yeah.
Q. Needles and fibers?
A. But can we go back just a little bit there?
Q. Yes, tell me --
A. The reason that I plot them up like you show there is that it's very difficult sometimes when you look at something to know whether it's a needle or a fiber or, you know, it's something that you have to count or not.
But if you have a population -- and we know what the population is because you just marked it. And when I go through and mine line up with that population, then I know it's asbestos. But if it doesn't line up -- it might line up over here with the other side, and then I would know it's not asbestos.
Q. Ah, okay. So the other side, because of the sizes and all, is more nonasbestiform, but this is asbestiform, or asbestos, because you've got this ratio down here that's so big; is that it?
A. Uh-huh. That's the way --

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that's --
Q. Okay.
A. -- their population.
Q. All right. So this is -- this is asbestiform asbestos that you were finding in the Johnson & Johnson baby powder that you pulled off the shelf?
A. Uh-huh.
Q. And you weren't doing this because anybody was paying you money to do it, or were you getting paid to do it?
A. No, I wasn't.
Well, I had some students working on some talc projects, I guess, so it may -- you know, I may have bought it then to show the students what it looked like, you know.
Q. All right. Part of your teaching?
A. Yeah.
Q. Okay. Very good.
I've got some more questions I can ask you that I want to ask you, but I think at this point I'm going to pause and let the other lawyers go because I'm going to